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SEPTEMBER, 1945

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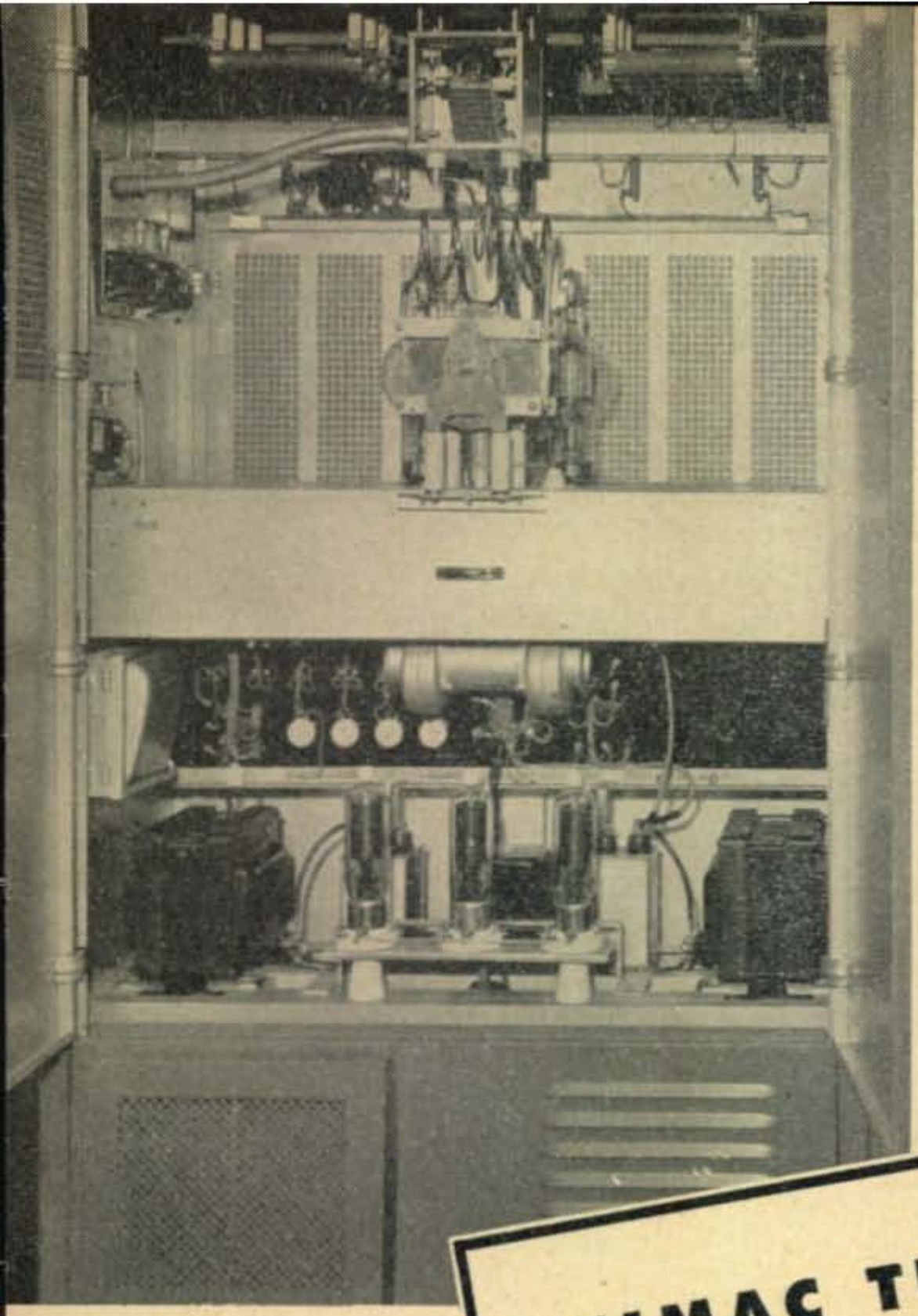
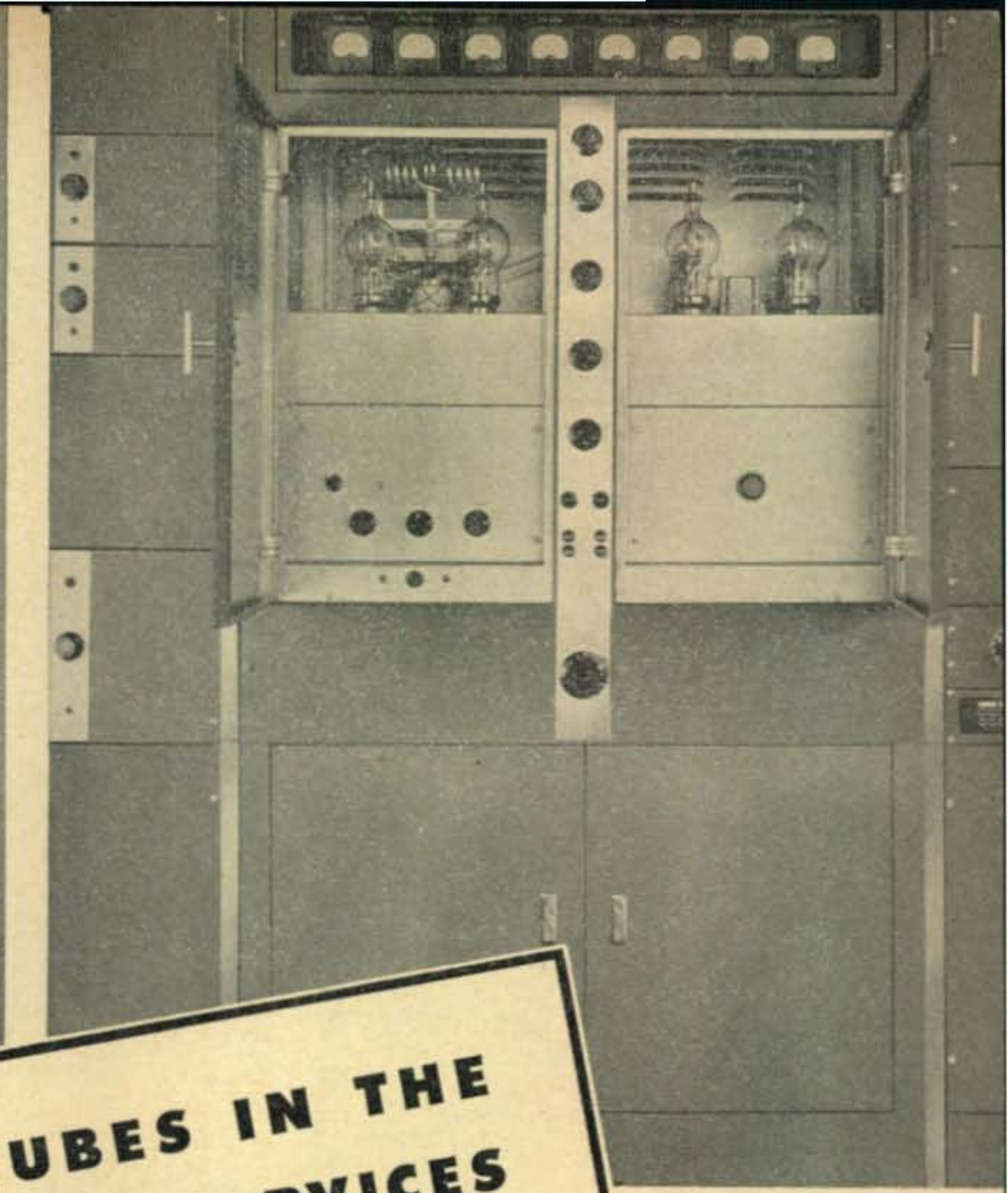
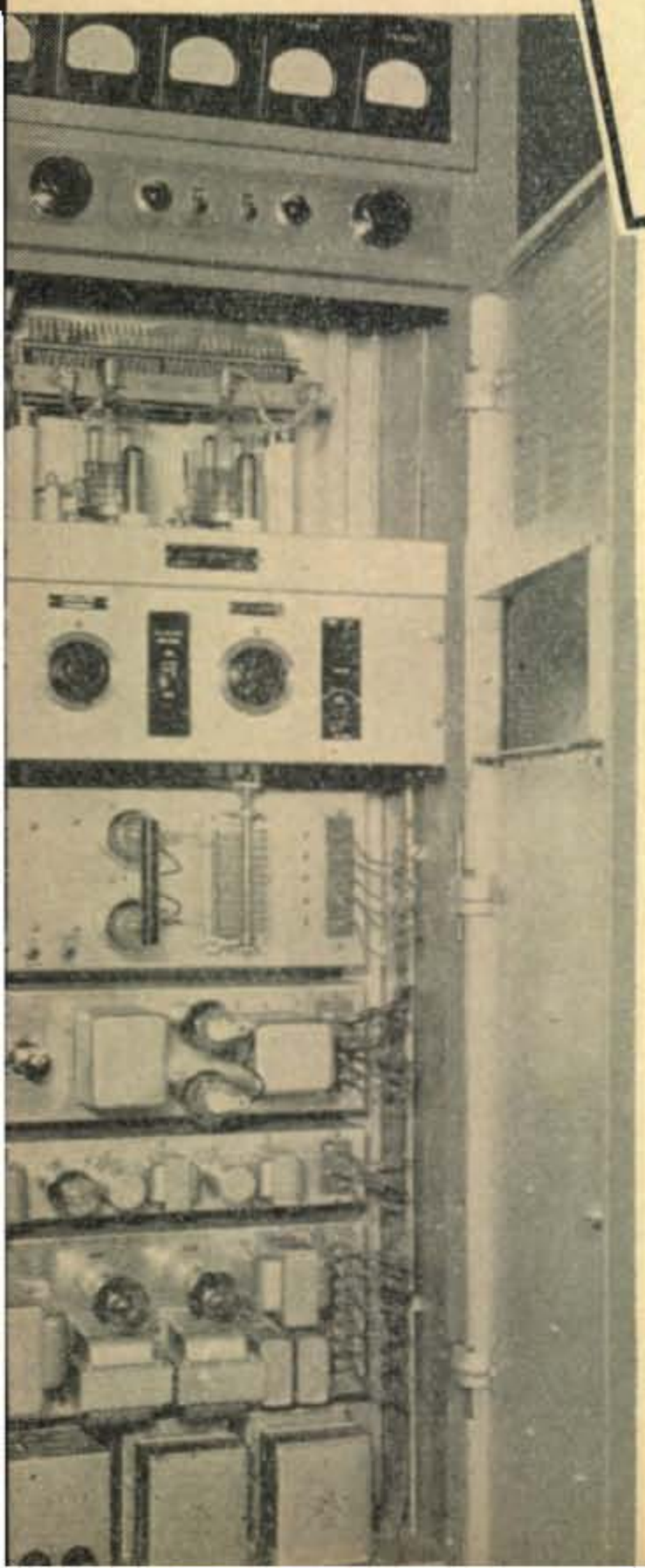


A pair of Eimac 1000-T's give 3 KW output in this Link-built FM transmitter for the emergency services.



500 watt AM police transmitter for 30-40 Mc operation, built by Fred M. Link, using Eimac 250-TH tubes in the final.

Here's a 500 watt supersonic test generator for operation at 1 to 300 kc which uses Eimac 152-T tubes.



EIMAC TUBES IN THE EMERGENCY SERVICES WHERE DEPENDABLE PERFORMANCE COUNTS!

The transmitters shown on this page were developed and built for the emergency services—police, fire and transportation—by Link Radio Corporation of New York City. Recognition such as that enjoyed by the Link organization in this field is built upon sound engineering and the right choice of equipment components. That Eimac tubes occupy the important sockets in these vital transmitters is fitting acknowledgement of their inherently superior performance capabilities. That Fred M. Link specifies Eimac tubes is confirmation of the fact that Eimac tubes are first choice of leading electronic engineers throughout the world.

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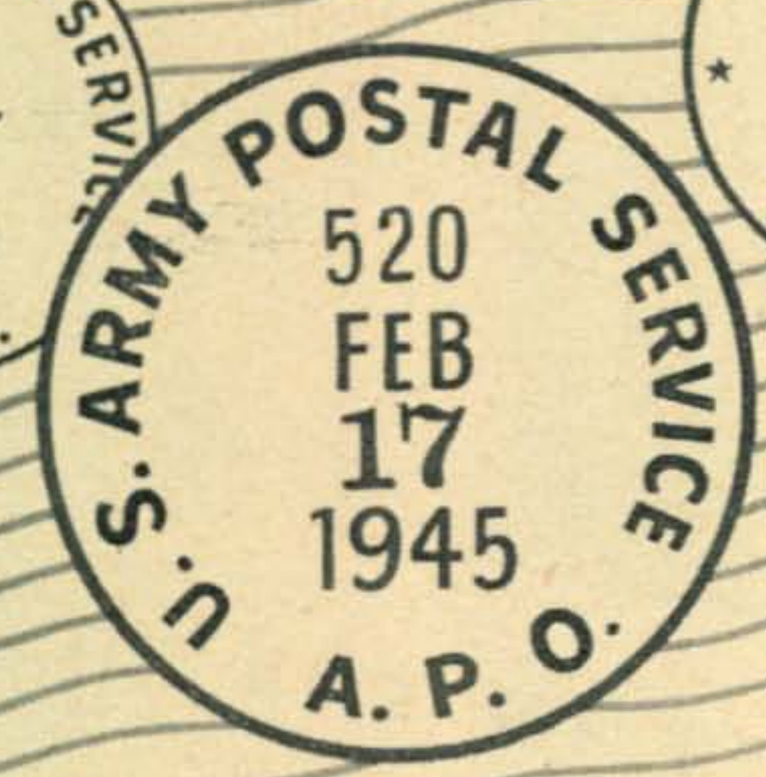

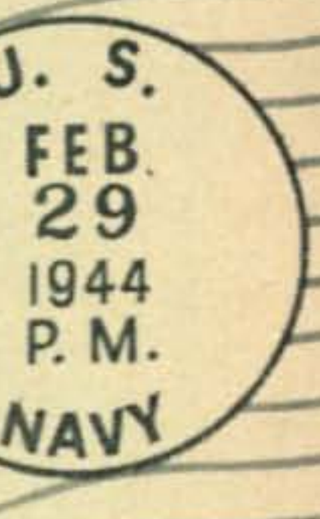

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The Radio Amateurs' Journal

Published by RADIO MAGAZINES, INC.

John H. Potts.....Editor
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SYLVANIA NEWS

RADIO AMATEUR EDITION

SEPTEMBER *Published by* **SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa.** **1945**

FORMER GOVERNMENT TUBE PURCHASES NOW AVAILABLE TO "HAMS"—SYLVANIA TESTED, GUARANTEED

Sylvania Electric announces the following tube types available, through Sylvania distributors.

Several of the types released are of particular interest to the amateur operator.

The current list is as follows:

38—Well known standard output pentode.

39/44—Well known standard R.F. Amplifier.

2X2/879—The standard high voltage, low current rectifier for oscilloscope use.

7C4/1203A—A small lock-in diode rectifier suitable for use in vacuum tube voltmeter probes. 6/3 volt 150 ma. heater.

7E5/1201—A lock-in triode for use as a low power oscillator or amplifier up to 750 mc. 6.3 volt 150 ma. heater.

46—Standard power amplifier. Suitable for Class B or C amplifiers and used in many amateur transmitters.

OD3/VR150—Well known voltage regulator.

EF-50—A 9 pin completely shielded R.F. Amplifier somewhat similar to Type 7W7. Heater rating 6.3 volts at 300 ma.

1626—A transmitting triode requiring 12.6 volts, 250 ma. heater supply. Four watts output at 250 volts plate (max.).

1629—Same characteristics as Type 6E5 except for octal base and heater rating of 12.6 volts, 150 ma.

38142 (VT-52)—Similar to Type 45 except for its filament rating of 7.0 volts, 1.18 amperes.

5BP1—Well known 5" cathode ray tube with the usual green trace. Makes a good scope with 1500 to 2000 volt anode supply.

5BP4—Same as 5BP1 except for the screen which gives a white trace.

VT-25A—This is the same as the regular Type 10 but has a low loss base. This item should be interesting to amateurs.

All tubes are available under the familiar L-265, or on rated orders.

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ZERO BIAS

A PROPHET BEING of no particular honor in his own country, we might refrain from an "I told you so" concerning our August editorial in which we deduced the possibility of an early and abrupt ending of the war with Japan, with the corollary that the FCC might find it feasible to reactivate amateur stations much sooner than expected. Within the month, V-J Day has come to pass, and the Board of War Communications has already notified the Federal Communications Commission that it has no objection to lifting the ham radio ban on 112-115.5 megacycles for a period of ninety days. "Before amateur activity may be resumed, appropriate action by the Commission will be necessary. It is expected that after ninety days the Commission will consider the advisability of authorizing amateurs to utilize the frequency band of 144 to 148 megacycles in lieu of the band 112 to 115.5 megacycles formerly allocated to the amateurs."

Your Editor has discussed this matter with Paul A. Porter, Chairman of the FCC, and has learned that, insofar as other bands are concerned, no action can be taken until they are released by the military authorities. While it is to be hoped that restrictions on these bands will be lifted with similar celerity, a *justifiable* delay (as contrasting with the red-tape variety) would not be intolerable. With immediate resumption of 112-115.5-mc transmission, the ham today is better off than his progenitor of 1918. We shall have been permitted to resume operation more quickly, and without practically rebuilding a station which may have been dismantled by order of the government. True, we are permitted only one of our bands temporarily—but there was only a single band back in 1918. To be sure, 112 or 144 megacycles is not a DX band—but neither was 200 meters twenty-seven years ago. Two hundred was used largely for local rag-chews in the immediate post-war period. While 144-148-mc operation may hold little allure for the 40 or 80-meter addicts, a large majority of the latter are still in the armed forces. On the other hand, it is probable that most of the hams at home, and ready to avail themselves of an FCC directive to open up, have 112-116-megacycle equipment on hand (which is readily convertible to 144-mc operation). Orderly reconversion to a peacetime radio set-up is probably just as important as in industrial adjustments. Both may be accomplished sooner than many are inclined to believe.

Whither the WERS?

It was only a few months back that the moribund War Emergency Radio Service received a shot in the arm, and seemed likely to carry on quite a while for general disaster communication in co-operation with the Red Cross. In the west, the WERS continued active on more of a war-time basis, with the citizenry still emergency-conscious as a result of the Jap balloon bombs—one of which was wafted as far east as Detroit. But it's all over now, and it would appear that the War Emergency Radio Service is finally defunct. It is unfortunate, because the work accomplished by the WERS was excellent, the well-disciplined organization functioned smoothly, and much money was invested in equipment. The WERS is virtually forced out of existence, and the 112-116-megacycle band they once occupied (as did the pre-war hams) has been assigned to government services.

A possible solution is to hold the organization intact—in everything except name—and effect the simple electrical shift to the 144-mc amateur band where, due to war-time training and discipline, it might function more effectively than the "Emergency Corps" of pre-Pearl Harbor days. Dropping the "W," the "Emergency Radio Service" would be composed of associate and full members—the latter being licensed amateurs. The "associates," of course, would be those patriotic citizens who secured restricted radiotelephone operator permits in order to operate with the WERS, but which class of license does not authorize the operation of an amateur station except under the personal supervision of a licensed amateur. However, there is no reason why the associates shouldn't be active in executive capacities, and in many instances be the guiding spirit in holding the WERS together and reconverting to the ERS. It would be one of the main jobs of the ERS hams, or full members, to assist the associates in obtaining amateur licenses. It should not be too difficult a chore, as the associates by now will have been thoroughly bitten by the bug!

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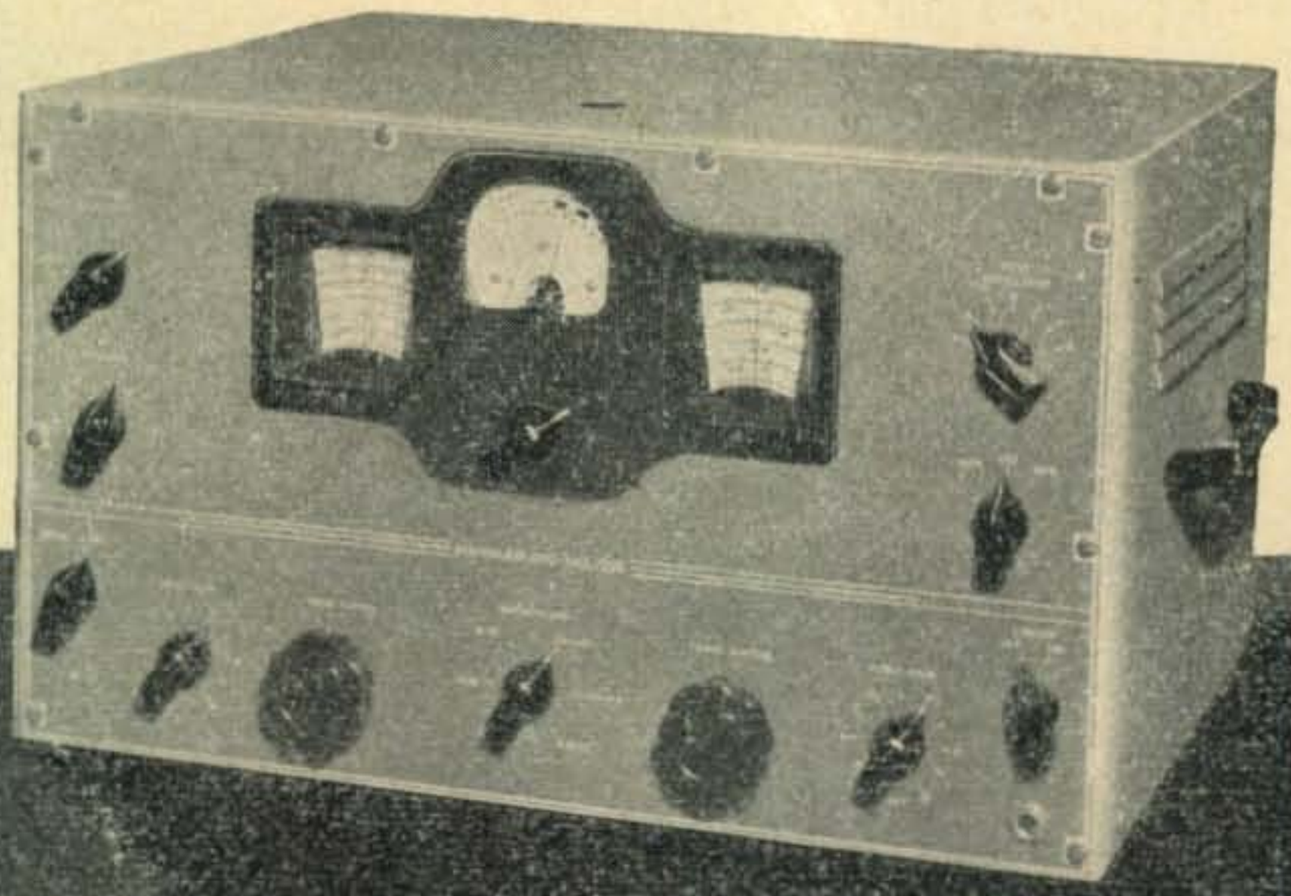

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EXCITER AND R-F AMPLIFIER FOR THE 144-148 MC BAND

A Simple Crystal-Controlled Unit for the New Ham Band

LEROY W. MAY, JR., W5AJG

THE FOLLOWING description of a 144-mc three-tube exciter unit with sufficient output to drive a single-tube 30-watt r-f amplifier, is pertinent, in view of the fact that the 144-148-mc band has definitely been set aside for amateur operation, and will replace the former 112-116-mc allocation.

The exciter portion of the rig is mounted on a masonite panel 8¾″ x 19″ to fit on a standard relay rack, while the single tube r-f amplifier occupies a 5½″ x 19″ panel of the same construction. To provide shielding between input and output circuits on the final the chassis plate of the amplifier is made of sheet aluminum 5½″ x 16½″. The two units are coupled by means of hairpin link coupling. (The exciter may be used with an antenna itself—although the useful power output is only on the order of a few watts operating at the given plate voltage.)

The Crystal Problem

Since this new ham band of 144-148 mc is not harmonically related to any of our previous assignments, the fundamental crystal frequency will have to be reconsidered so as to provide

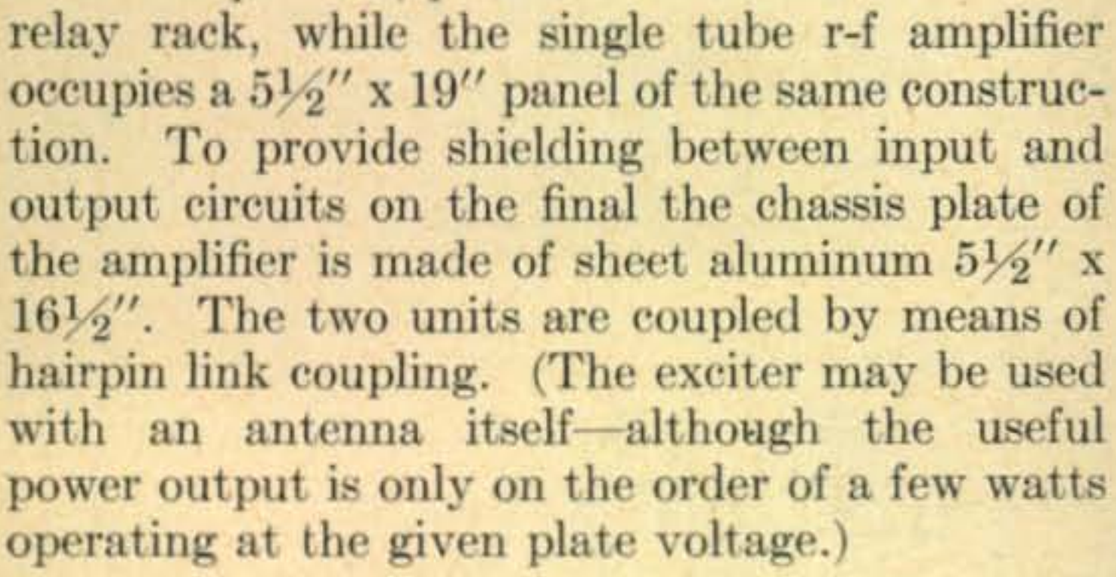


Fig. 1. Under view of the exciter unit. The 832 stage is at the upper right, with bypass condensers grouped around this socket. The socket at the upper left furnishes power to the amplifier

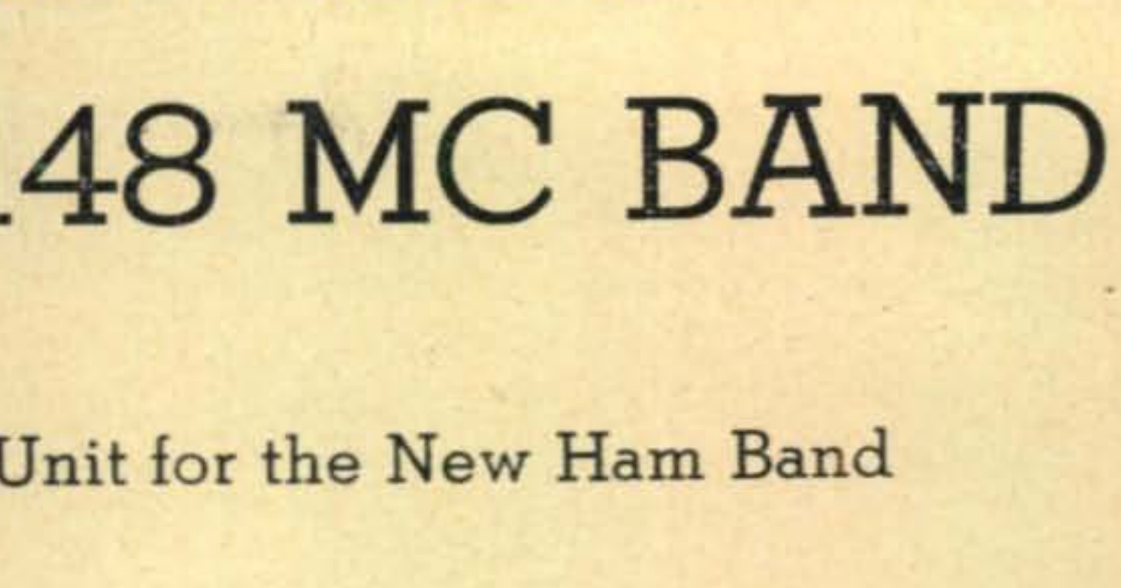


Fig. 2. The exciter unit as seen from above. The plate lines are held in place with stand-off insulators, and the output coupling hairpin is mounted on feed-through insulators

proper final multiplication. Quite a few combinations are possible. To maintain the number of exciter stages at three and still reach the new band, a crystal whose fundamental frequency was somewhere between 6,000 kc and 6,166 kc was selected. At present it may take a little ingenuity to obtain a crystal plate between these frequencies. As a hint, contact your ham friends who work with aircraft radio equipment. A blank or plate may be found and dressed up with a little rubbing. In any event, the rig can be tuned using a 7-mc crystal, and when crystal plates around 6-mc become plentiful only moderate retuning will be necessary.

Using a plate of this frequency allows a 6L6 quadrupling tri-tet crystal oscillator to 24 mc—which is easy. The second stage is a 6L6 doubler to 48 mc. Stage number 3 is a tripler to 144 mc. This is also simple—with the proper tube, which turned out to be the dual beam 832 good for full ratings to 200 mc. Used as a push-pull tripler with resonant plate lines, it is a smooth worker, and, as before stated, may be used to feed the antenna directly with a few watts output. While only 300 volts are used on the 832 as a tripler, this potential could be increased to 500

and more output secured if it is desired to feed the antenna. Plenty of driving excitation is available from the 6L6 doubler. The efficiency of this tripler stage is estimated as between 35 and 40 percent.

The final amplifier employs another type 832, as a straight amplifier. Again using resonant lines in both plate and grid circuits, the estimated efficiency of this Class C amplifier is a conservative 65 percent. More about this later.

Constructional Details

As can be seen from the photographs of the exciter unit, *Figs. 1, 2* and *3*, the input power socket is at the left back of the masonite chassis. The crystal socket follows—then the 6L6 oscillator and finally the 6L6 doubler. The metal type is preferable in this latter stage as less lead inductance is present. While the glass tube is satisfactory, a little more output is usually

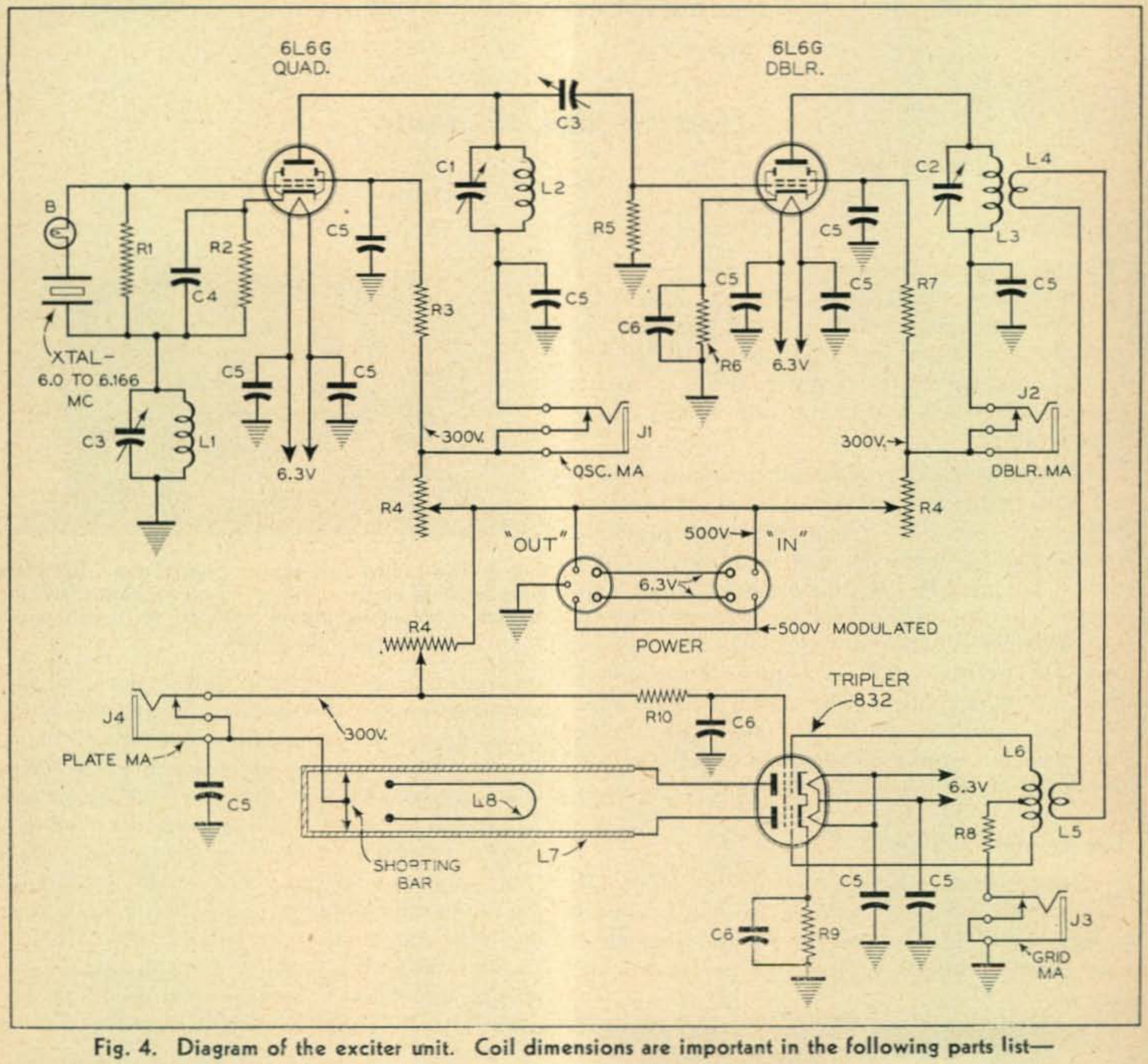


Fig. 4. Diagram of the exciter unit. Coil dimensions are important in the following parts list—

B—50-ma flashlight bulb
C_1—100 $\mu\mu$f midget variable
C_2—50 $\mu\mu$f midget variable
C_3—3-30 $\mu\mu$f mica compression trimmer
C_4—.002 μf mica
C_5—.005 μf mica
C_6—.0005 μf mica
J_1—Osc. plate ma jack, insulated
J_2—Dblr plate ma jack, insulated
J_3—Tripler grid ma jack
J_4—Tripler plate ma jack, insulated
L_1—12 turns No. 26 DCC 1½" form ¾" long
L_2—7 turns No. 12 enamel 1" dia. 1" long
L_3—4 turns No. 12 enamel 1" dia. 1" long
L_4 and L_5—2 turns No. 12 enamel 1" dia. close-spaced
L_6—12 turns No. 12 enamel 1" dia. 1¾" long
L_7—3/8" dia copper tubing spaced 1½" center-to-center 14" long
L_8—No. 10 bare copper wire 6" long U-shaped
R_1—75,000 ohms ½ watt carbon
R_2—500 ohms 2 watts carbon
R_3—20,000 ohms 2 watts carbon
R_4—5,000 ohms (with slider) 25 watts
R_5—150,000 ohms ½ watt carbon
R_6—500 ohms 5 watts
R_7—10,000 ohms 10 watts
R_8—25,000 ohms 1 watt carbon
R_9—2,500 ohms 10 watts
R_{10}—15,000 ohms 10 watts
XTAL—Between 6.0 and 6.166 mc

available with the metal type. The 832 tripler, with associated plate lines, is at the front. This layout provides for short leads and simple construction. Filament and plate power to drive the 832 straight-through amplifier is obtained from the 5-prong socket which can be seen at the extreme front left.

Taking the stages in order—referring to the circuit schematic *Fig. 4*—the 6L6 crystal oscillator is the conventional tri-tet with the plate circuit tuned to the fourth harmonic of the crystal plate, or 24 mc. A good active crystal and low-loss plate tank circuit are essential if sufficient output is to be obtained—a well-established practice. The plate potential here is 300 volts and also on the doubler and tripler tubes. Individual dropping resistors are provided for each stage, though a single resistor of the proper wattage can of course be used.

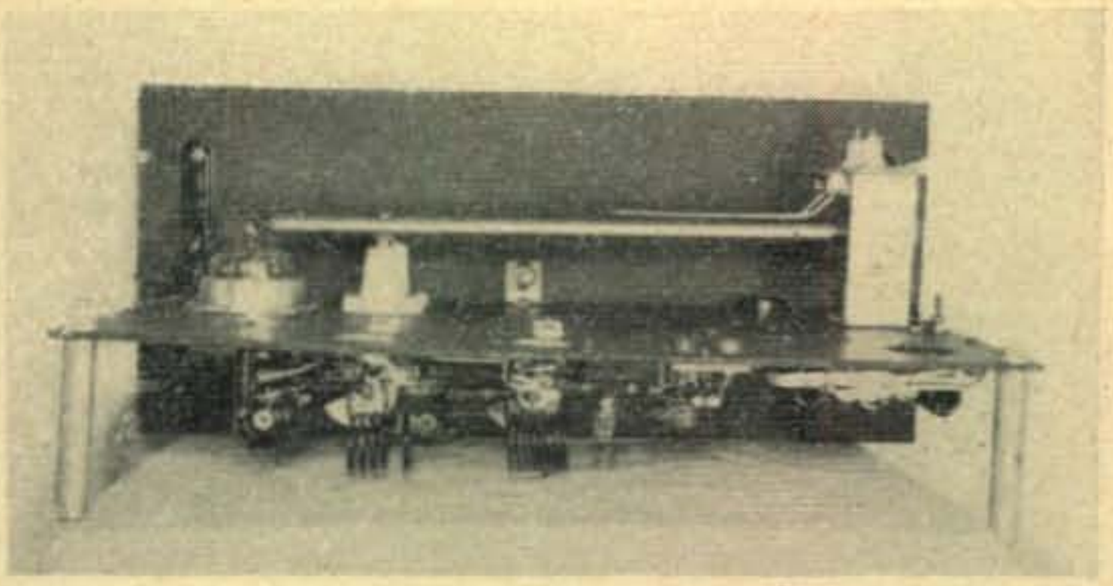
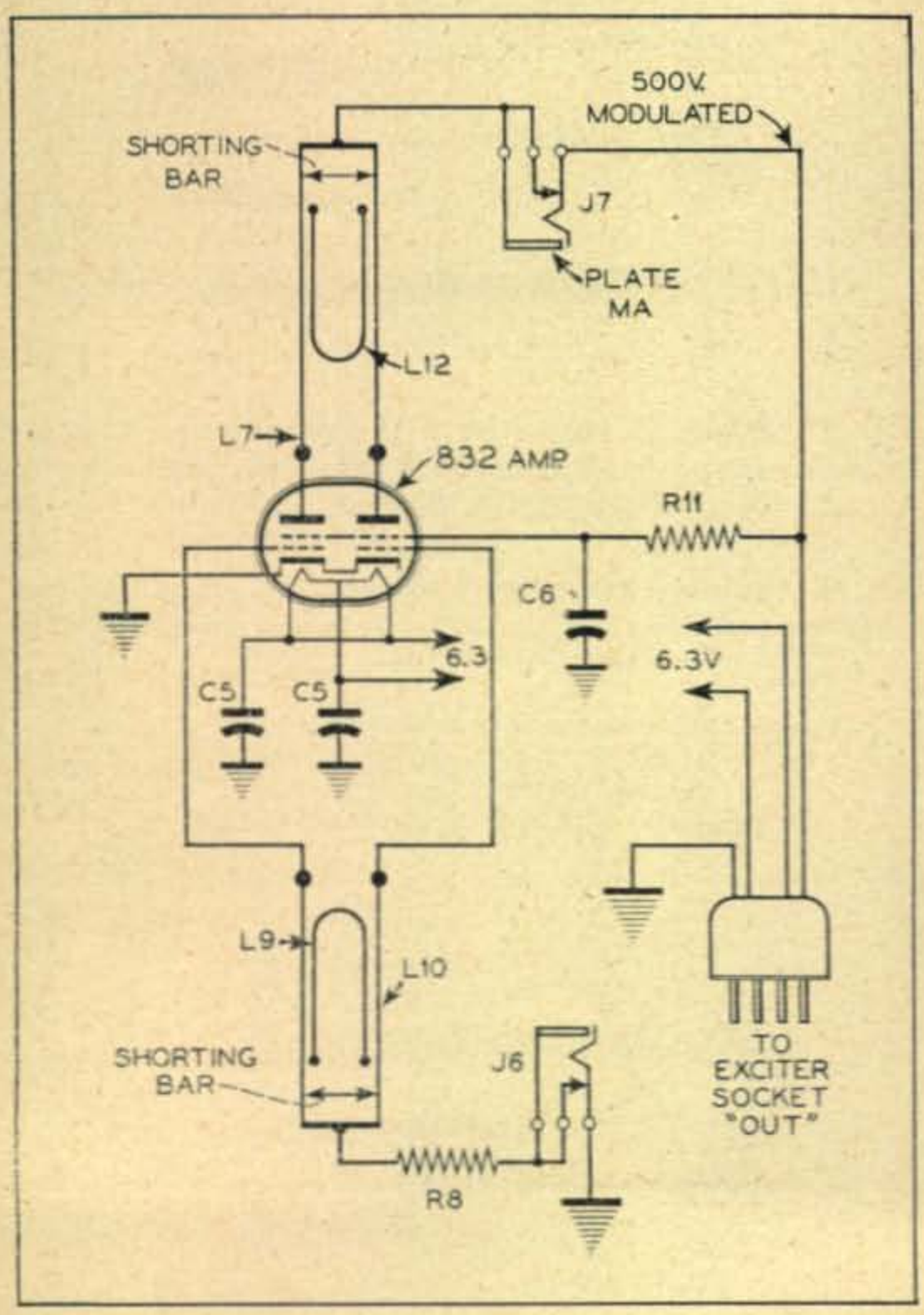


Fig. 3. Further mechanical details are shown in this rear-view photo of the exciter unit. The xtal and 6L6G tubes have been removed

Fig. 5. Amplifier circuit for 30 watts input. The following parts are used—

C_5—.005 μf mica
C_6—.0005 μf mica
J_6—Amplifier grid ma jack
J_7—Amplifier plate ma jack, insulated
L_9—No. 10 bare copper wire 5" long U-shaped
L_{10}—¼" copper rods 1" spacing center-to-center 9" long
L_{11}—3/8" dia. copper tubing spaced 1½" center-to-center 14" long (same as L_7)
L_{12}—¼" copper tubing spaced 1½" center-to-center 14" long
R_{11}—30,000 ohms 1 watt
R_{12}—25,000 ohms 1 watt



The 6L6 doubler is excited through a 3-30 μμf trimmer-type condenser which is very convenient for proper adjustment and is recommended instead of the usual 50 μμf fixed mica capacitor. Such a coupling condenser can be adjusted for peak output and load on the crystal oscillator. As in the oscillator stage, a good low-loss variable condenser and tank coil, mounted so as to have very short leads, or preferably mounted directly upon the tuning-condenser, are desirable. No trouble should be experienced here as operation is perfectly normal. However, a loop-type absorption wave-meter is a practical necessity. Time out should be taken to build one, if none is already available. Since the frequencies involved in multiplying are a bit different from the more familiar ones of past days, a little experimenting will be necessary to calibrate the meter. By listening on a receiver, the 24-mc harmonic is easily identified when tuning the oscillator stage through resonance. The crystal plate tank will also allow tripling with the constants shown and this 3rd harmonic, or 18 mc, is to be avoided. The 48-mc output from the doubler can hardly be missed as it is the only harmonic that falls within the L/C range of the coil and condenser. This is also true of the 144-mc tripling stage if the plate rod spacing as shown in the circuit diagram caption is followed. While the 5th harmonic or 240 megacycles is discernible, this is only when the shorting bar is within a few inches of the plate—an obviously improper setting.

The push-pull 832 tripler is perhaps the easiest to get going of any stage—assuming the previous two stages are lined up and operating. The input grid coil, which is link coupled to the 6L6 doubler, is made self-resonant with the tube capacity and adjusted by spreading or squeezing the turns. It may be seen from the photograph showing the under side of the exciter (*Fig. 7*) that quite a respectable coil is necessary, attesting to the fact that the 832 has a low input capacity—actually 7.5 μμf.

It is stated in the tube manual that the total grid circuit resistance of the 832 should not exceed 25,000 ohms per tube or 50,000 ohms per unit.

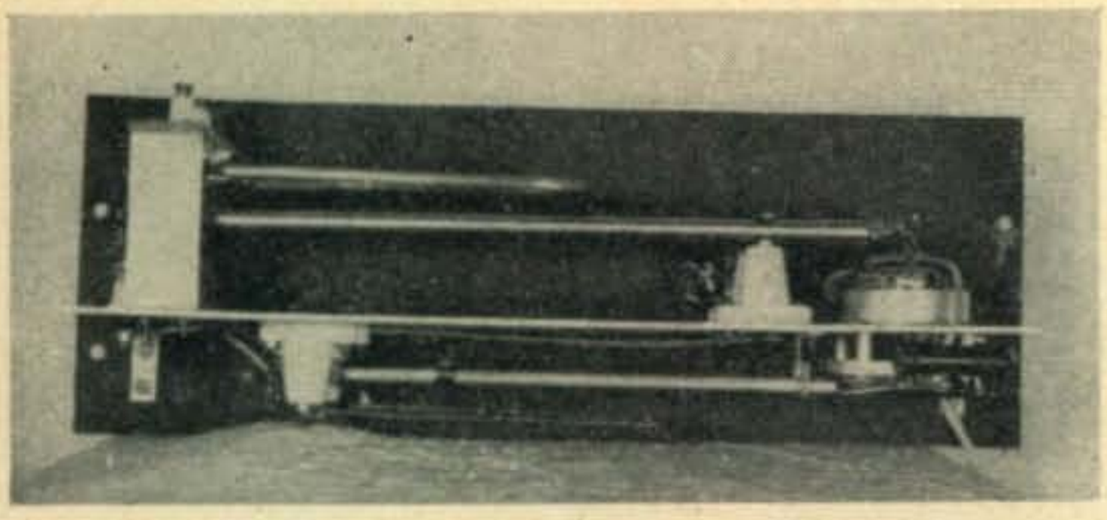
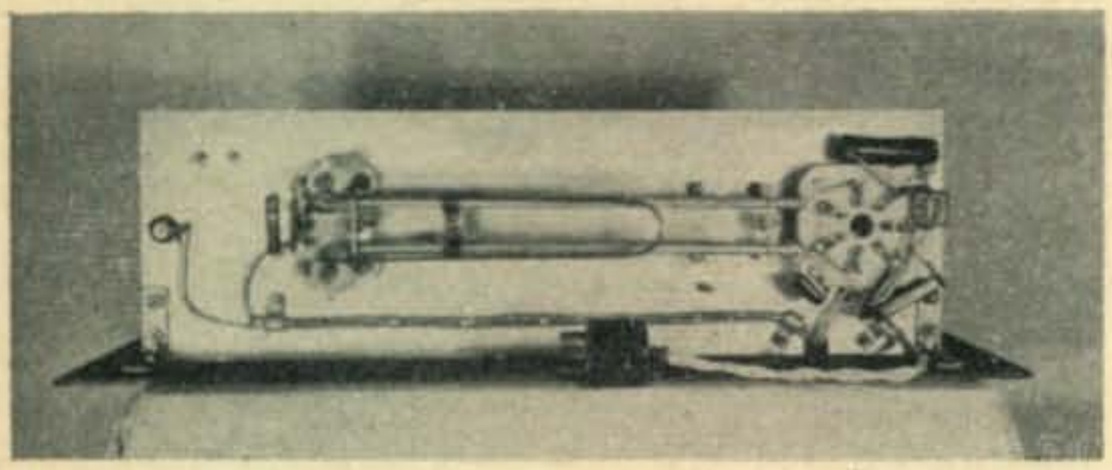


Fig. 6. (Above) Rear view of the amplifier unit. The aluminum chassis plate serves as a shield between the exciter and amplifier. The input coupling hairpin is beneath the chassis plate

Fig. 7. (Below) Underneath the amplifier chassis. The 5-prong plug fits the socket in the exciter to furnish plate and filament power to the amplifier. Again by-pass and screen components are grouped around the 832



This does not provide sufficient bias for proper tripler operation. To obtain the necessary remainder for a plate flow angle of 60 degrees, a cathode bias resistor of 2,500 ohms is also employed. Plenty of drive from the 48-mc doubler is obtained for tripler operation, and, as previously stated, an estimated efficiency of around 35 to 40 percent is obtained. With 300 plate volts on the tripler, resonance at the third harmonic of 48 megacycles (144 mc) is indicated by the usual plate current dip as the shorting bar is slid along the rods. This dip will probably be more pronounced than the dips in the oscillator, quadrupler or the 6L6 doubler circuits.

One precaution to be observed when using the 832 tripler is to make certain that the heater potential is a full 6.3 volts. Poor tripling action was corrected when the writer discovered that the filament transformer was only putting out 5.25 volts under load although the 6L6's stages were operating satisfactorily at this reduced voltage.)

Some experimentation was tried with the plate and grid resonant rods to determine the optimum spacing. For maximum Q or selectivity, the conductor radius should be about one-fourth of the center-to-center line spacing. However, for higher impedance, which is usually desired in anything but oscillator control, a higher ratio is desirable. The chassis will accommodate about 14 inches of line, so 3/8" copper tubing spaced 1½" was selected. Actually, the sliding shorting bar will be set about an inch from the shorted end for the low-frequency end of the band. The flexible connections to the plates of the 832 tripler are about 3/8" long. The output hairpin link for the exciter is approximately 6 inches long and is formed into proper shape with No. 10 solid bare copper wire.

Amplifier Details

The 832 r-f amplifier is mounted on an aluminum chassis plate with the grid line and pickup hairpin on the bottom of the plate and the plate line and antenna hairpin on the top side of the chassis plate. Thus the shielding between input and output circuits is complete and no neutralizing is required. The grid circuit resonant lines, differing somewhat from the tripler and amplifier plate lines, are ¼" copper rods spaced one inch center to center and 9" long. This shortens the total length and simplifies placement of parts. The grid link hairpin is a piece of No. 10 solid bare copper wire five inches long—similar to that of the tripler described above.

The final amplifier is simplicity itself. The circuit is shown in *Fig. 5*, and constructional details indicated in the photographs, *Figs. 6, 7* and *8*. The input grid shorting bar is adjusted for maximum rectified grid current. About 3 ma will amply drive the 832 and this is, of course,

[*Continued on page 40*]

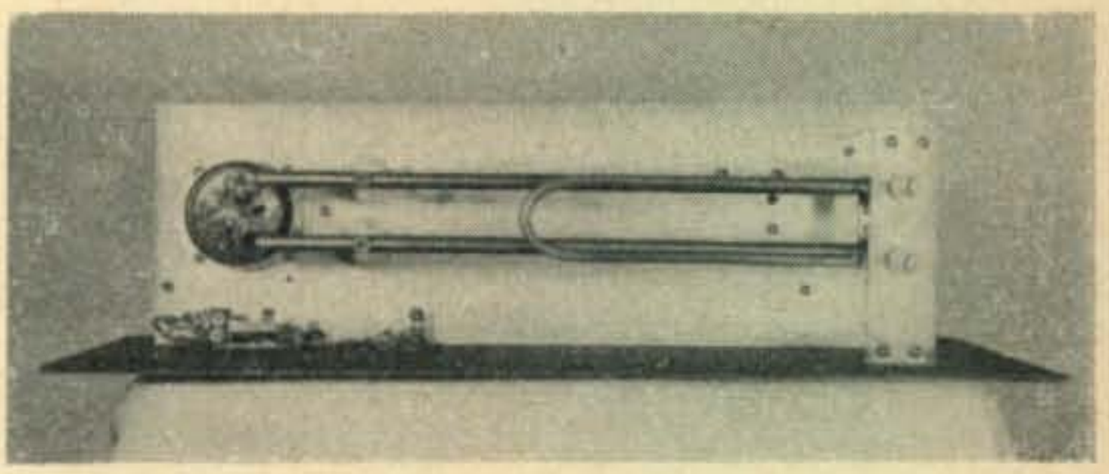
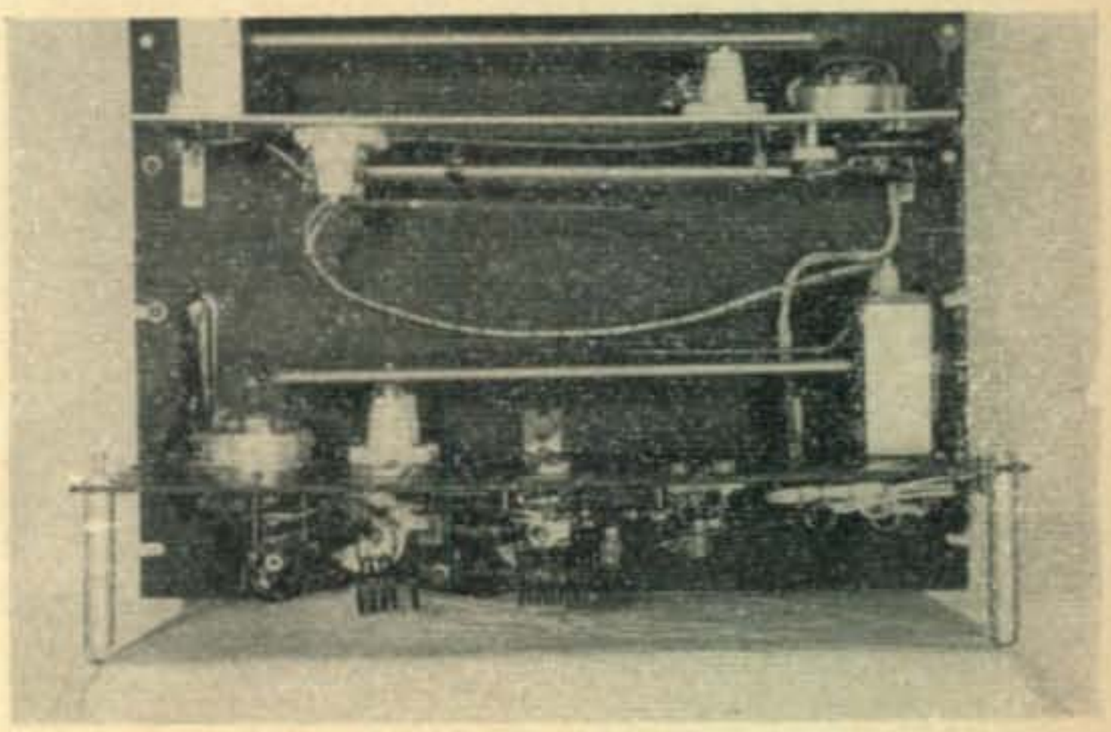


Fig. 8. (Above) Top side of the amplifier. The plate lines are supported by stand-off insulators similar to the exciter set-up. Plate and grid circuit jacks are at the left

Fig. 9. (Below) Completed exciter and amplifier combination already to go as soon as tubes are plugged in (and the FCC says OK)



DON'T LET IT PHASE YOU!

FUNDAMENTALS OF PHASE RELATIONSHIP IN ELEMENTARY CIRCUITS, AMPLIFIERS AND ANTENNAS

W. H. ANDERSON, VE3AAZ

THE OLD MAXIM that a picture is worth a million words is perhaps nowhere more directly applicable than in the case of circuit action analysis. All but a very small minority of circuits are concerned with alternating currents and voltages, especially those of a sine type, where the waves of current or voltage at a certain point in the circuit will be similar in form to a related wave at some other point. However, the waves may be considerably displaced from one another in regard to time. It will be noted from some of the subsequent examples that the time relationship very largely determines the behaviour of the circuit. This displacement is termed a difference

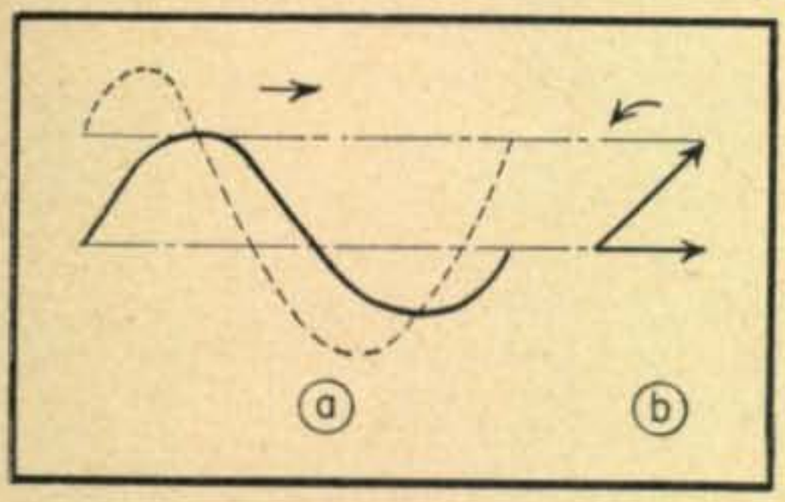


Fig. 1. Time difference in a sine wave expressed as a curve (a) and as a vector (b)

in "phase" and is generally expressed in degrees, with 360° representing a complete cycle.

Two possible methods of portraying such a condition are shown in *Fig. 1*—in this case, two unequal sine waves displaced by 45°. A further distinction is made by the terms "lag" or "lead." In *Fig. 1* the dotted wave is said to lead—a passage of time being by convention denoted by movement to the right as in (*a*), or in counter-clockwise rotation (*b*). Obviously a lag of X° could also be described as a lead of (360-X)° and vice versa, so it is not customary to speak of phase angles exceeding 180°. The comparative

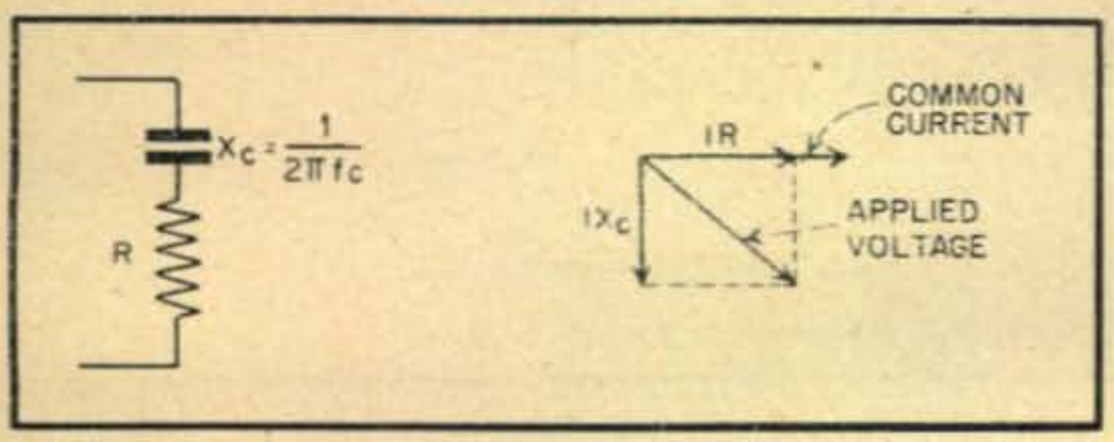


Fig. 2. Vector representation of a series circuit

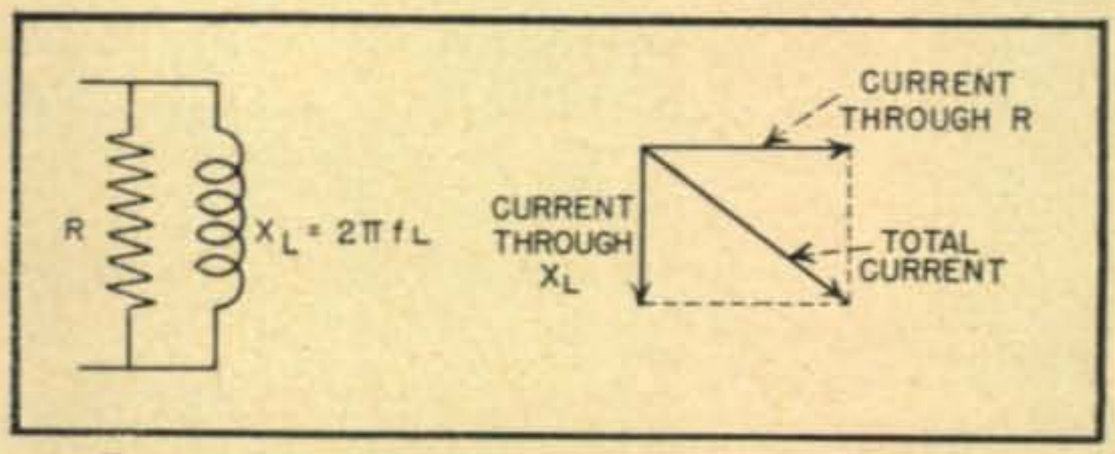


Fig. 3. Phase relationships in a parallel circuit

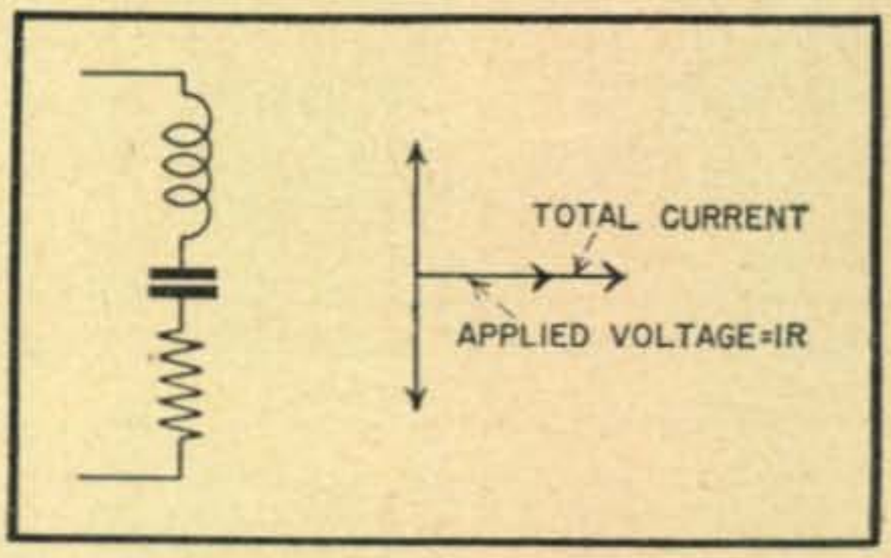
simplicity of *Fig. 1*(*b*) as against (*a*), naturally leads to the greater popularity of the "vector" diagram, rather than bothering to draw the various sine waves.

If the frequency of the wave is known, the phase angle can be translated into terms of time. This is often done in video amplifiers to ascertain if a certain phase delay or lead will blurr the image on the screen.

Basic Electrical Laws

In any analysis of phase relationships, it must be borne in mind that actually two separate cir-

Fig. 4



A series resonant circuit—when X_C equals X_L

cuit conditions are being compared—in other words, at least three and often four terminals are involved. To speak of a phase shift occurring "across" any single element may lead to quite erroneous conclusions.)

Considering it axiomatic that the voltage across and current through a pure resistance are in phase, the various fundamental electrical laws relating to phase shifts may be tabulated as follows:

1. The current through a condenser leads the

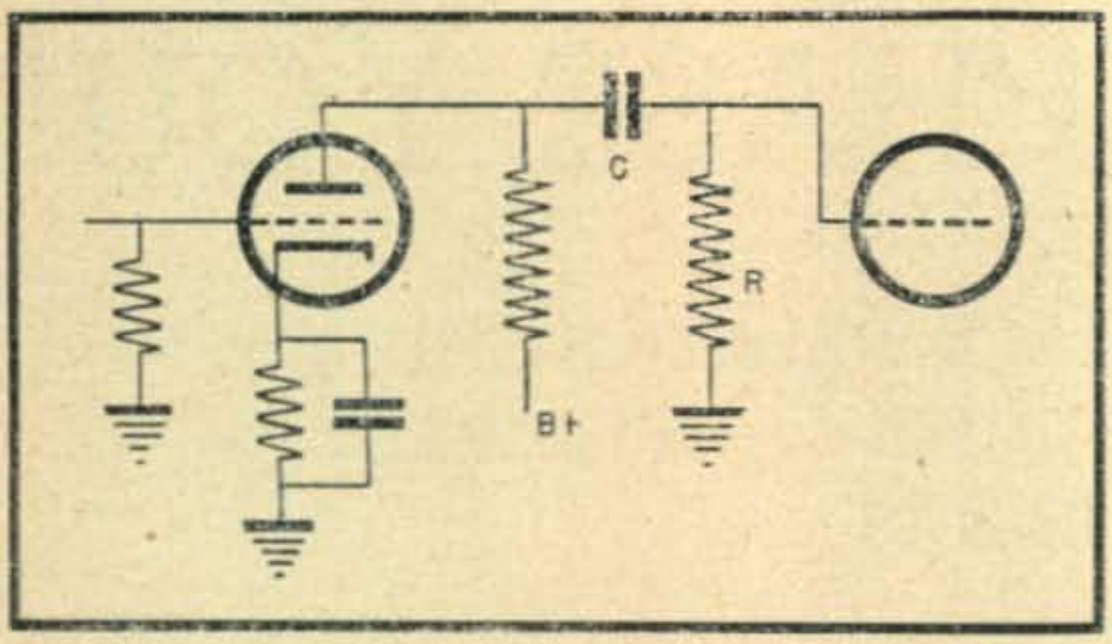


Fig. 5. Conventional diagram of a triode resistance-coupled amplifier

voltage across it by 90°. Corollary—The voltage lags the current by 90°.

2. The current through an inductance lags the voltage across it by 90°. Corollary—The voltage leads the current by 90°.
3. In any series circuit, regardless of the number of elements, the same current flows through each member.
4. In any parallel circuit, the same voltage is applied to each *branch*.
5. In any inductively-coupled circuit, the secondary couples into the primary an impedance which is some fraction of the secondary *series* impedance, depending on the degree of coupling, but with the sign *reversed*.
6. In any inductively-coupled circuit, the voltage induced will act in series with the secondary and lag the current in the primary by 90°.
7. In the secondary of any coupled circuit, the current flow due to the induced voltage will depend on the characteristics of the secondary series circuit without regard to the primary.

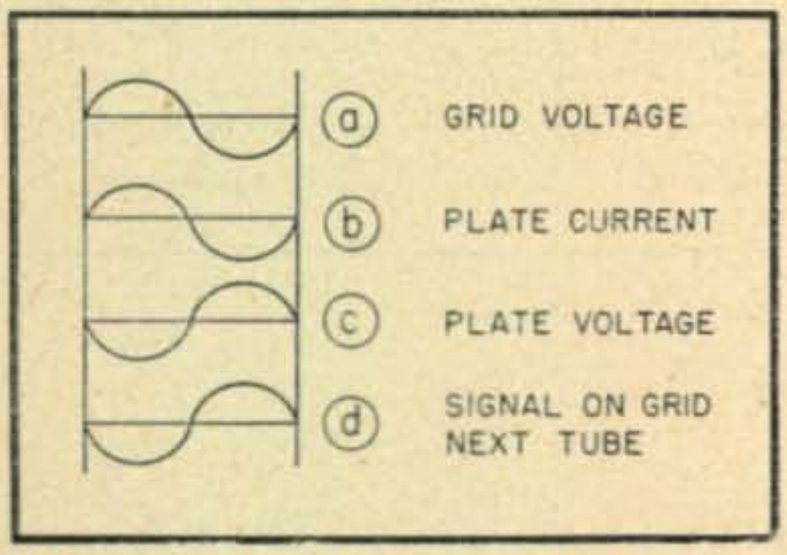


Figure 6

Phase relationships as existing in the circuit of Fig. 5

Method of Application

To draw the vector diagram of any circuit, the procedure is to select some voltage or current as a reference vector and lay it off horizontally and to the right of the point of origin. Then the various other vectors are drawn from the origin at appropriate angles from this reference vector. Since the convention is for vectors to rotate counter-clockwise, any vector pointing upward will be ahead of the reference vector and conversely any vector pointing downward will be behind or lagging, unless of course, it is desired to speak in terms of angles greater than 180°.

The simplest type of circuit will be of the form of *Fig. 2*. Since the current in this case is common to both elements, its vector is laid out a random length horizontally. A vertical distance downward from the origin and a length along the horizontal are marked off in proportion to the magnitude of the capacitive reactance and resistance respectively. These vectors actually represent the voltages across the two elements, but since the current is common and unknown, obviously the voltage drops will bear the same proportion as the impedances. The vector for the condenser

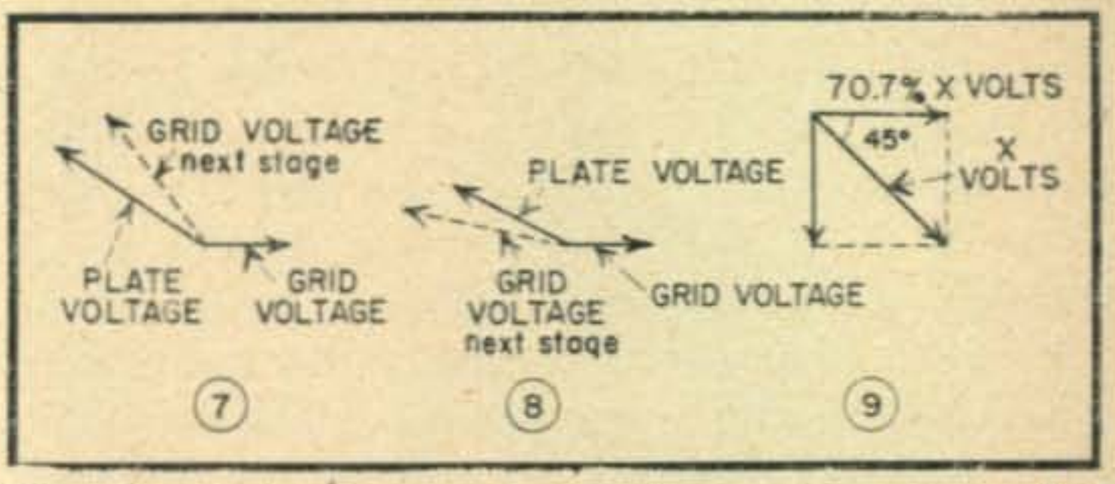


Fig. 7. How the action of the resistance-coupled amplifier looks in vectors at high frequency

Fig. 8. R-C amplifier relationships at low frequencies

Fig. 9. Critical phase shift in the coupling circuit

is drawn downward as the voltage across a condenser lags the current through it (*Rule 1*).

A rectangle is then sketched, the diagonal representing the applied voltage. This will determine the scale if the applied voltage is known. Also, conclusions may be drawn as to the angle of voltage lag behind the current (or what is exactly the same thing, the current lead ahead of the voltage) for the circuit as a unit.

In the case of parallel circuits, *Fig. 3*, the applied voltage is common, and is laid off along the horizontal axis. The currents are then calculated —applied voltage over resistance (E/R) and applied voltage over inductive reactance (E/X_L) —laid off in appropriate directions, the rectangle completed, and the total current determined.

The circuit in *Fig. 4* involves two types of reactance. Vectors are plotted as before, the vectors in quadrature with the reference vector

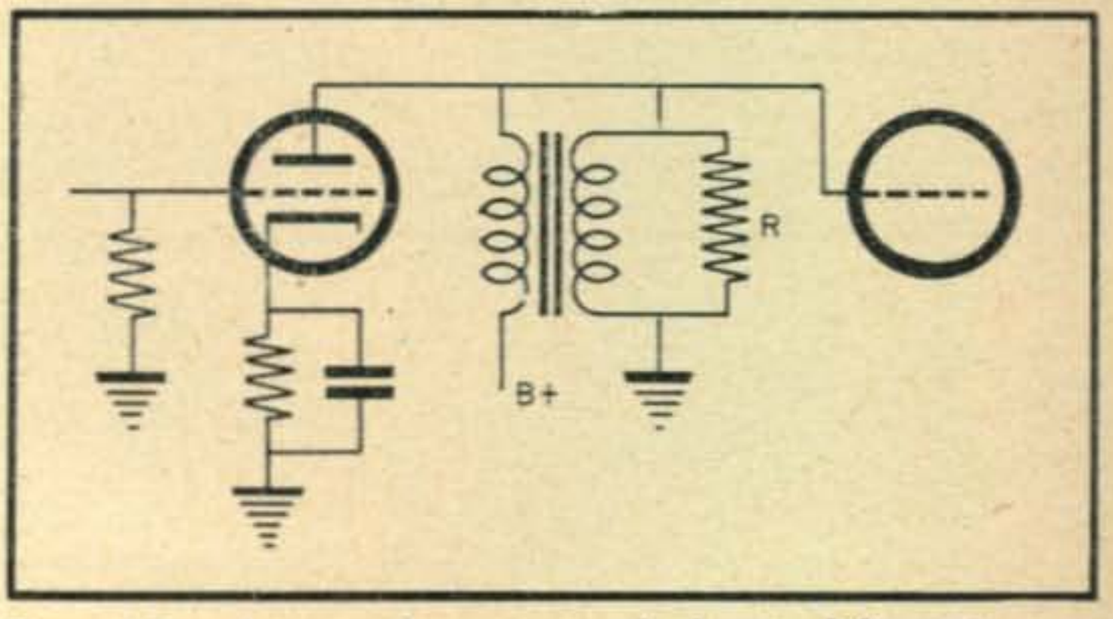


Fig. 10. A transformer-coupled amplifier stage—interstage or output

being subtracted before being combined with the in-phase vector to find the resultant. It can be readily deduced that if, in such a case, the reactances were equal (resonance), the circuit would act as a pure resistance. Complex circuits with many branches and elements can be similarly analyzed by combining elements and recombining resultants as in the above, and those interested in the refinements of such procedures should consult any good electrical engineering text.

Barring resonance (when reactances are equal) it may be seen that in circuits such as the foregoing: *1*—The current through the combination is not in phase with the applied voltage. *2*—The voltages and currents in any one circuit element alone are not necessarily in phase with the resultant voltages and currents. *3*—The amount of lag or lead depends on the proportion of resistance/reactance present. *4*—Since all such calculations depend on the reactance of the element, which is a function of the frequency, the computations must be repeated for as many frequencies as are being investigated.

Resistance Coupled Amplifiers

A conventional resistance coupled amplifier stage is shown in *Fig. 5*. If we assume a sine

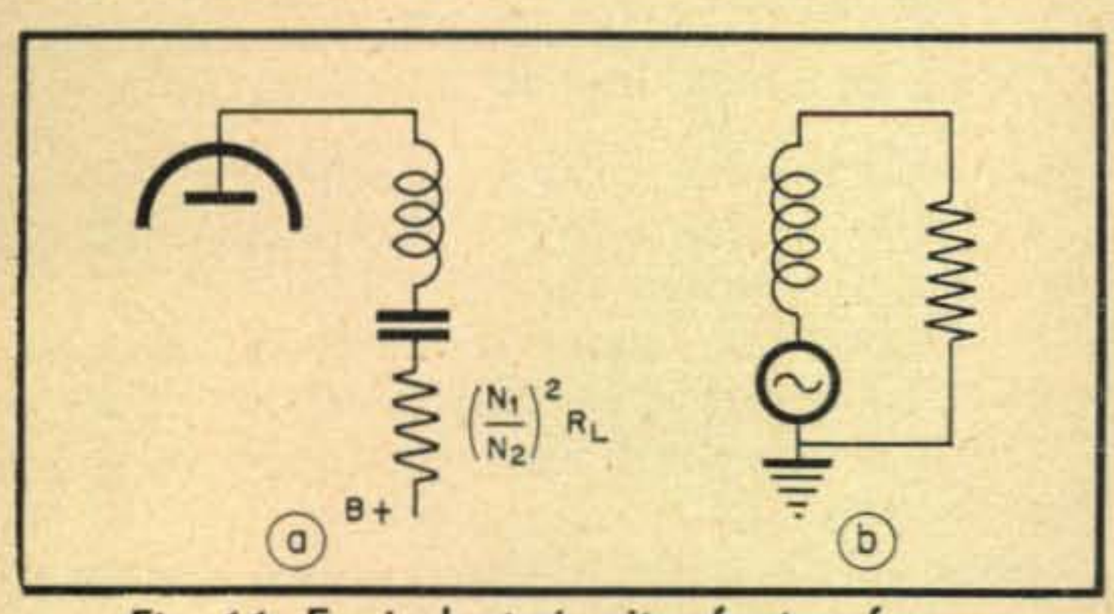


Fig. 11. Equivalent circuits of a transformer

wave of voltage on the grid, *Fig. 6* (a), as grid becomes more positive the plate will draw more current, causing the voltage drop across the load resistor to increase, and simultaneously the voltage at the plate to *drop*. Thus the plate current is in phase with the grid voltage, while the plate output voltage is 180° out of phase with the grid voltage. This fact gives rise to the minus sign in the familiar theorem that any such stage may be considered as a generator whose output voltage equals $-\mu E_g$ volts, where μ is the amplification factor and E_g the grid voltage.

The coupling condenser (C) and grid resistor (R) of the following stage therefore comprise a series circuit fed by the alternating voltage across the load resistor. As the resulting current in such a case depends largely on the proportion of the capacitive reactance of C as compared with the resistance of R, if C has a large capacity (and consequently low capacitive reactance) and R

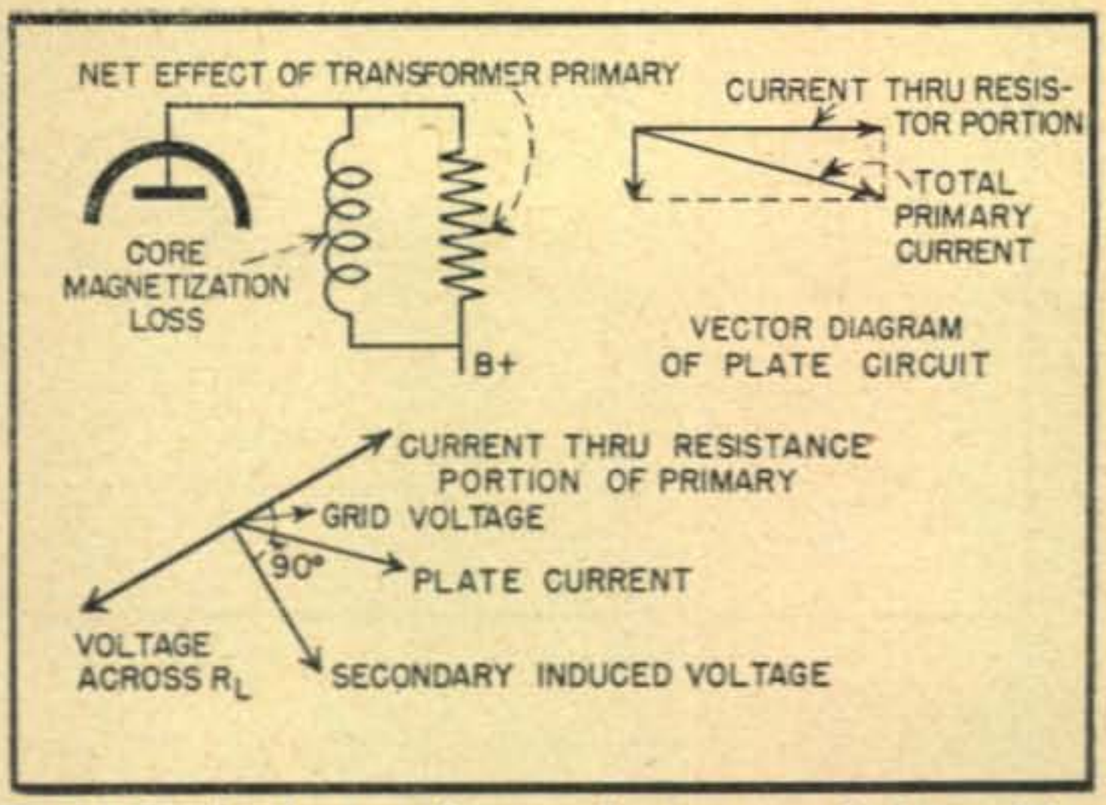


Fig. 12. Analyzing the transformer-coupled amplifier at low frequencies

is a high resistance, the current flowing in R (and therefore the voltage impressed on the grid of the next stage) will be substantially in phase with the plate output voltage. Thus there will be a total of slightly under 180° phase shift between *grids* of such successive stages.

Note that at low frequencies when the reactance of C becomes greater, the current through R will tend to lead the plate output voltage and a phase shift will be introduced by the coupling device. High-frequency phase shift in such circuits is occasioned by the fact that the grid-to-cathode capacitance of the following stage shunts R, and its reactance becomes low enough to affect circuit behaviour at the high frequencies. The preceding stage now acts as a source driving this capacitance, and the voltage across it will lag the current.

In both the low and high-frequency cases, the situation is further complicated by the fact that the plate load is not now purely resistive. It has a capacitive component, so the plate voltage leads the grid voltage by less than 180°, or, if you prefer, it lags by more than 180°. This will aggravate the phase shift in the high-frequency case (see *Fig. 7*), but be somewhat compensatory in the low-frequency instance as in *Fig. 8*.

At low frequencies, assuming the reactance of the C equal to the resistance of R, and drawing the vector diagram as in *Fig. 9*, it is obvious that the voltage across R is 70.7 per cent of the stage output voltage. This will be recognized as the

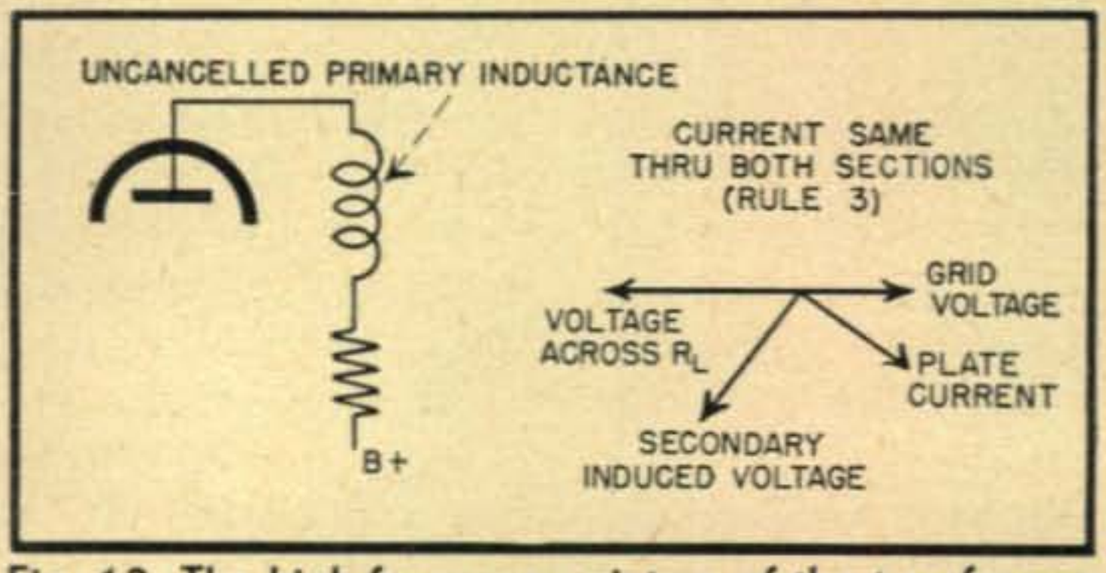


Fig. 13. The high-frequency picture of the transformer-coupled amplifier

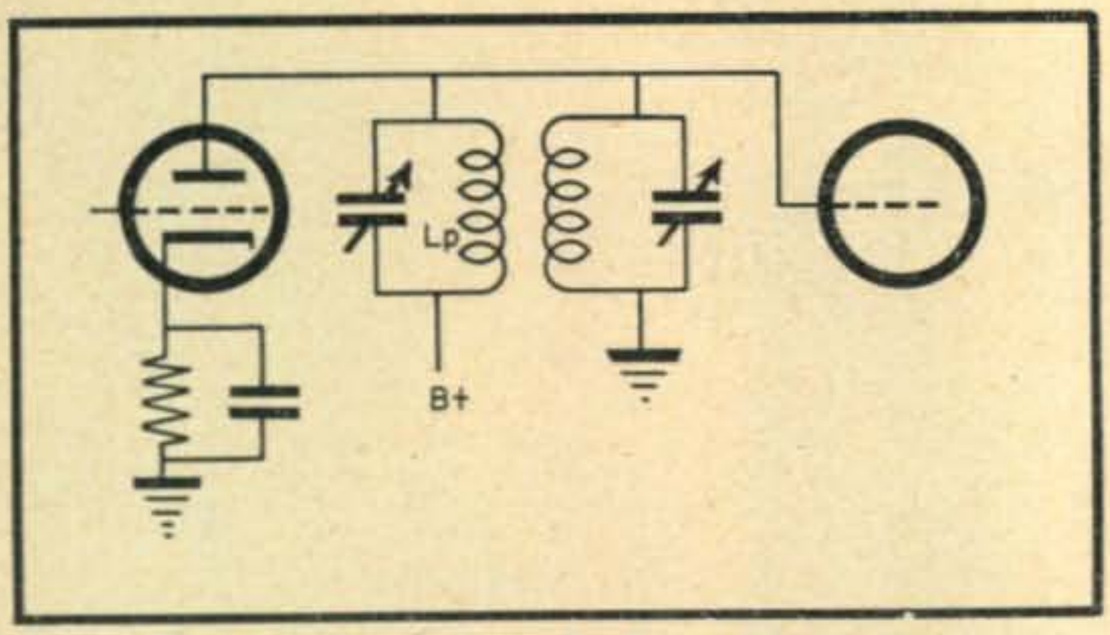


Fig. 14. Fundamental r-f amplifier stage

critical point often assumed in amplifier design formulae, and represents a 45° phase shift in the coupling network itself.

This delay or lead of some frequencies in comparison to others is termed "phase distortion" and is not ordinarily detectable by ear, but can be seen to be inseparably associated with a discontinuity in response. As mentioned above, such distortion will be objectional in video amplifiers.

Transformer Coupled Amplifiers

A somewhat different method of analysis applies to the audio amplifier terminating in a transformer, (*Fig. 10*). In describing the action of a transformer, it is often stated that its primary presents to the exciting source a resistance equal to the load resistance multiplied by $(N_1/N_2)^2$, where N_1/N_2 is the primary-to-secondary turns

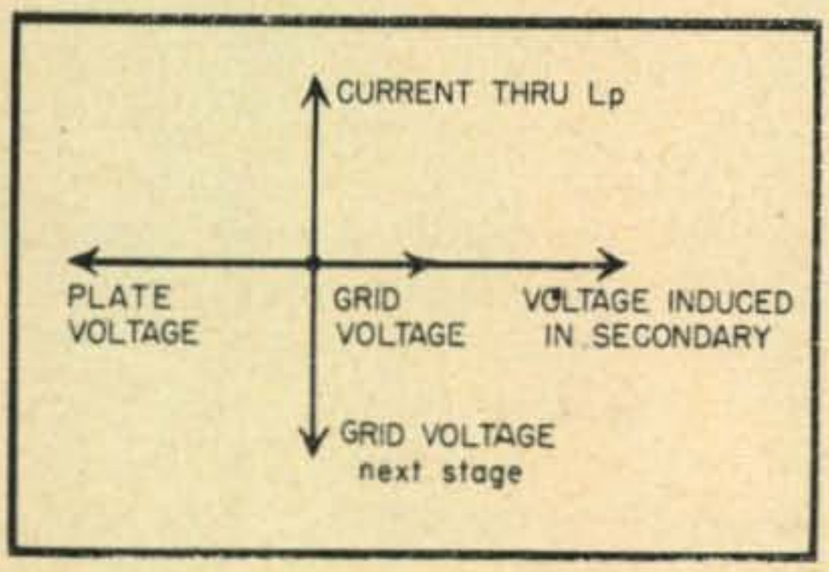


Fig.15. Vector analysis of the r-f amplifier

ratio. What this actually means is that the secondary couples into the primary a capacitive reactance and a resistance in series, the capacitive reactance being just sufficient to cancel the inductive reactance of the primary winding. In other words the primary is a series resonant circuit similar to *Fig. 11*(a), the coupled resistance being all that the exciting source "sees" upon looking into the circuit. In such a circuit the current will be in phase with the applied voltage. Considering the secondary, *Fig. 11*(b), the conditions in this circuit are as though a generator had been inserted in series with it. This generator produces a voltage that lags the current in the primary by 90° (Rule 6). Furthermore this generator faces a circuit that is predominantly inductive, so that the current through R will lag the *induced* voltage by another 90°. As the voltage across R is in phase with the current through it, this voltage will be a total of 180° out of phase with the current through the primary. Consequently the grid to grid shift will be 180° (*Fig. 10*).

In actual practice, these ideal conditions are scarcely realized. The coupling between primary and secondary is never perfect, so not quite all of the primary inductive reactance is cancelled out, and a small reactance remains in series with the resistance. Due to the loss entailed by the primary magnetizing the core, another reactance will appear in shunt with the primary. At high frequencies the series reactance will be of importance, and at very low frequencies the shunt reactance will affect the operation. Both will cause the plate current to lag the grid voltage. *Fig. 12* represents the conditions in the low-frequency case. The total primary current lags the

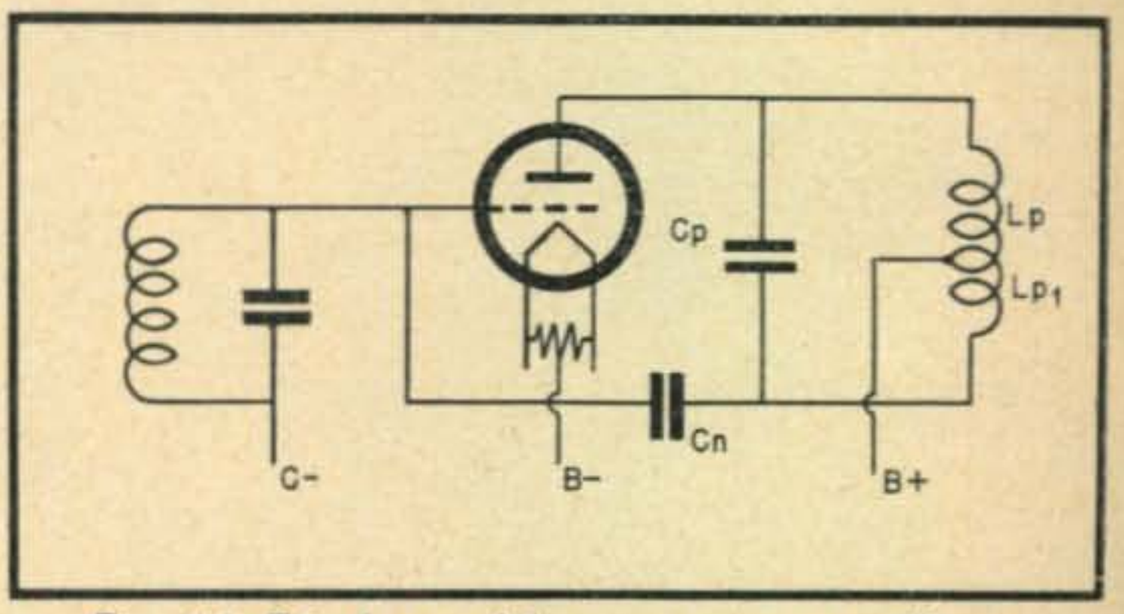


Fig. 16. Triode amplifier stage as an oscillator

grid voltage; the current through the resistive branch leads this current. The induced voltage will lag the current through the *resistive* branch by 90°, and the voltage across R will lag the induced voltage by something under 90°. Thus the voltage across R will always lag the grid voltage by less than 180°. The somewhat different conditions in the high-frequency case are shown in *Fig. 13*, where the primary current lags the grid voltage and the induced voltage will therefore lag the grid voltage by more than 90°. With the voltage across R lagging by something under 90°, it is seen that it is possible to have a condition where the grid voltage and the voltage across R will be 180° out of phase. Should there be a capacitive load across R the voltage across it will

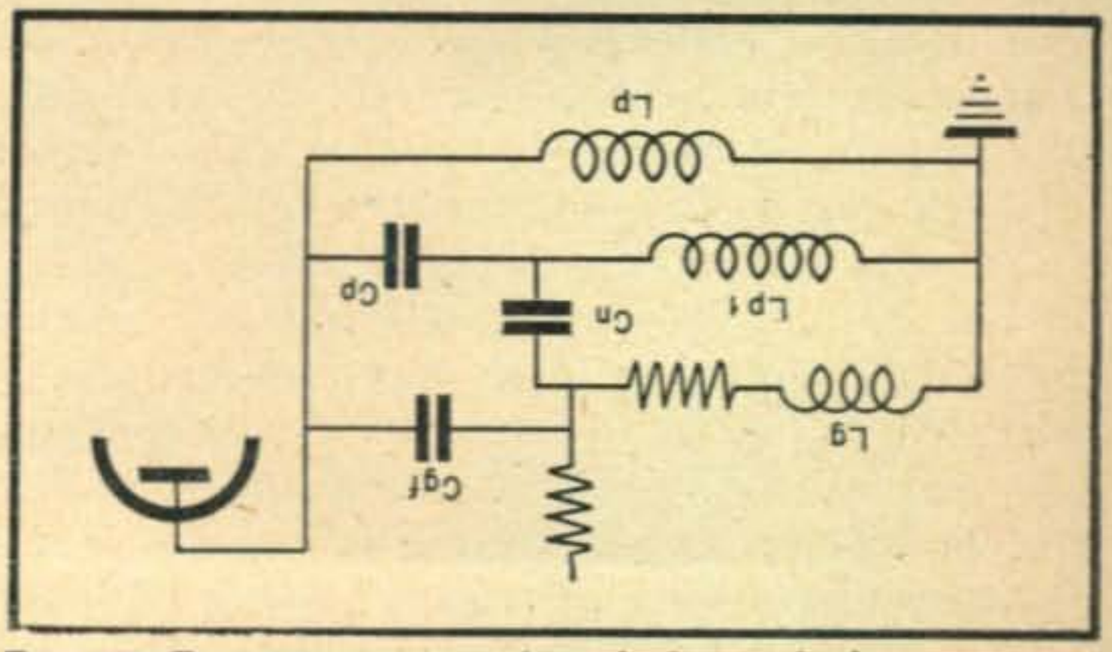


Fig. 17. Fig. 16 rearranged, with the grid-plate capacity shown as C_{gf}

then lead somewhat and the grid to grid shift will be less than 180°. Both interstage and output transformers face loads that vary widely between highly reactive and resistive characteristics, and their behaviours can therefore be less accurately predicted than a resistance coupled amplifier at a given frequency.

R-F Amplifier Stage

Another circuit commonly encountered is that of *Fig. 14*. This presents a different problem due

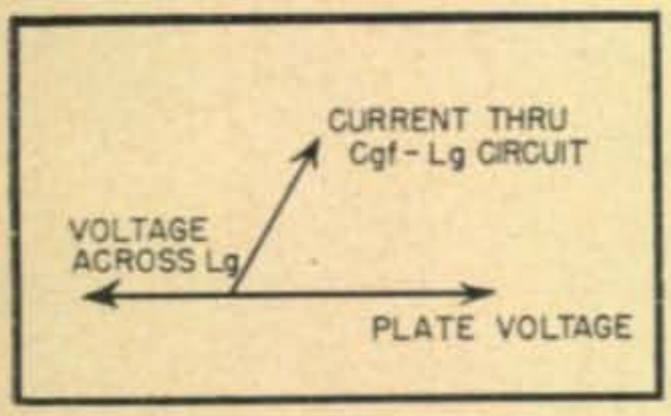


Fig. 18. Vector diagram showing how the grid-plate provides regeneration (feedback) and oscillation

to the fact that the primary inductance is part of a parallel resonant circuit. In such a circuit the current through the coil will lag the applied voltage by 90°. The effect of the secondary, as before, is to couple into the primary a small capacitance and resistance; but in ordinary applications this has negligible effect on the primary inductance—in fact this accounts for the slight retuning necessary when a tank circuit is loaded. The induced voltage in the secondary, which will be 90° behind the primary current, faces a series resonant circuit, and it is desired to find the phase of the voltage being supplied to the grid of the next stage, which will be that appearing across the condenser. Since the current through the secondary is in phase with the induced voltage, the potential across the condenser will lag the induced voltage by another 90°. Therefore there has been a total of 270° lag (equivalent to a 90° lead) between the voltage applied to the primary parallel resonant circuit and the voltage available across the secondary condenser. *Fig. 15* is there-

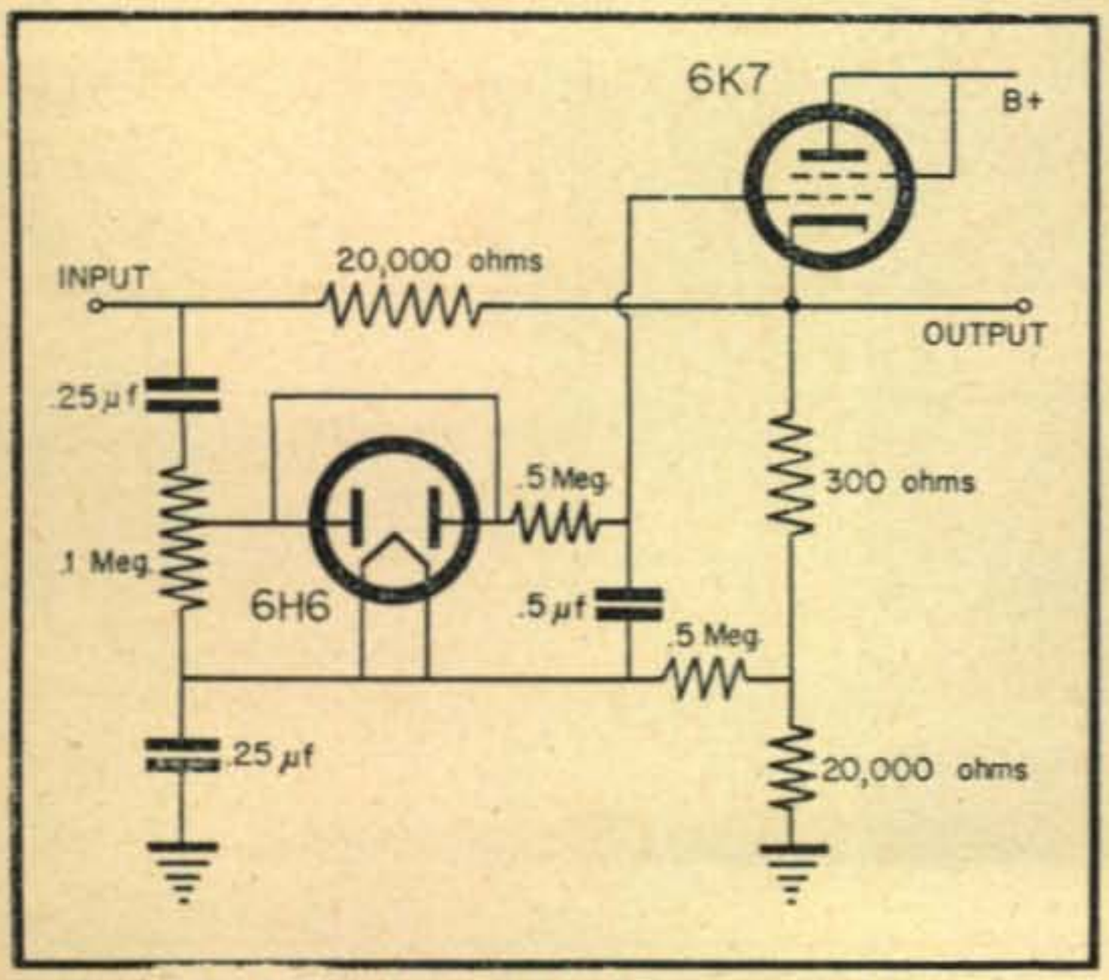


Fig. 19. A fundamental volume-expander circuit

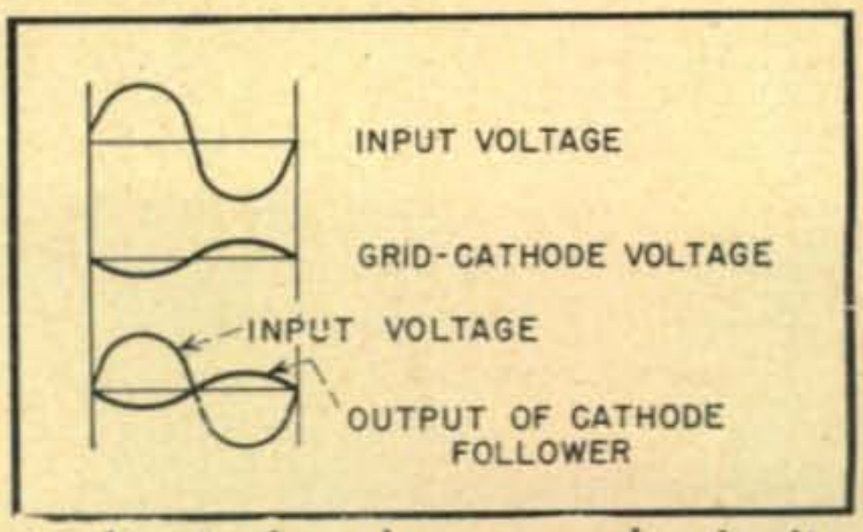


Fig. 20

Phase relationships in the volume-expander circuit

fore a vector diagram of conditions existing in *Fig. 14*, taking into consideration the 180° phase shift due to the plate load working against B+.

Oscillators

It may be deduced from the previous sections on amplifiers that when the grid voltage rises, the plate voltage drops. If the drop in plate voltage could be made to cause a decrease in grid voltage, the effect would be cumulative, and the output of the stage would excite its own input, and we would then have an oscillator. *Fig. 16* shows a conventional triode amplifier stage, while *Fig. 17* is a rearrangement showing the plate-grid capacity of the tube as a condenser and the grid circuit tuned to such a point that it represents an inductance and resistance in series. If we consider the plate voltage as the reference vector (*Fig. 18*), the current through the C_{gf}-L_g

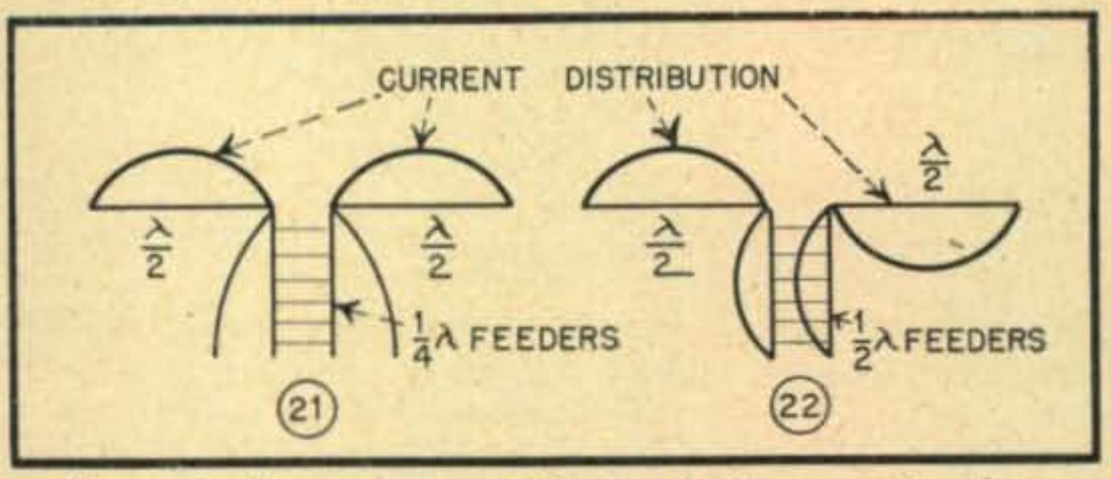


Fig. 21. An antenna with two half-waves in phase
Fig. 22. Half-waves out of phase in an antenna

circuit will lead this voltage (C_{gf} predominates), and the voltage appearing across L_g will lead this current approximately another 90°. Thus, ignoring the neutralizing condenser for the moment, the plate and grid voltages will be approximately 180° out of phase and oscillation will occur. By a similar method of reasoning, it may be deduced that the plate voltage and the voltage across L_p, will be 180 out of phase. When the neutralizing condenser is brought into play, these 180° opposing voltages will both be fed into L_g and when equal, will cancel, and the stage will cease to be oscillatory. However, when the neutralizing condenser is increased beyond this point, an interesting shift takes place. The frequency of the oscillator then moves to a point slightly higher than the resonant frequency of the grid circuit, and the circuit between the grid and ground appears as a condenser in series with a resistance.

[*Continued on page 35*]

PANORAMIC

A Visual Method of Reception which makes it possible to *See* Signals on each side of a Tuned Station—with Ham Possibilities Galore

THE "PANORAMIC" concept is full of practical ramifications. This article, intended primarily for the amateur and short-wave listener, deals with one application, the "*Panadaptor*"—but the reader must not conclude that this represents the only use either in civil or military radio. Technically, "Panoramic Reception" is defined as the simultaneous *visual* reception of a multiplicity of radio signals over a broad band of frequencies. More simply, and especially as applied to the adaptor, Panoramic Reception provides an indication of the frequency, type, and strength of the various radio signals which are present in a given receiver. Deflections or peaks appearing as inverted V's (*Fig. 1*) on the screen

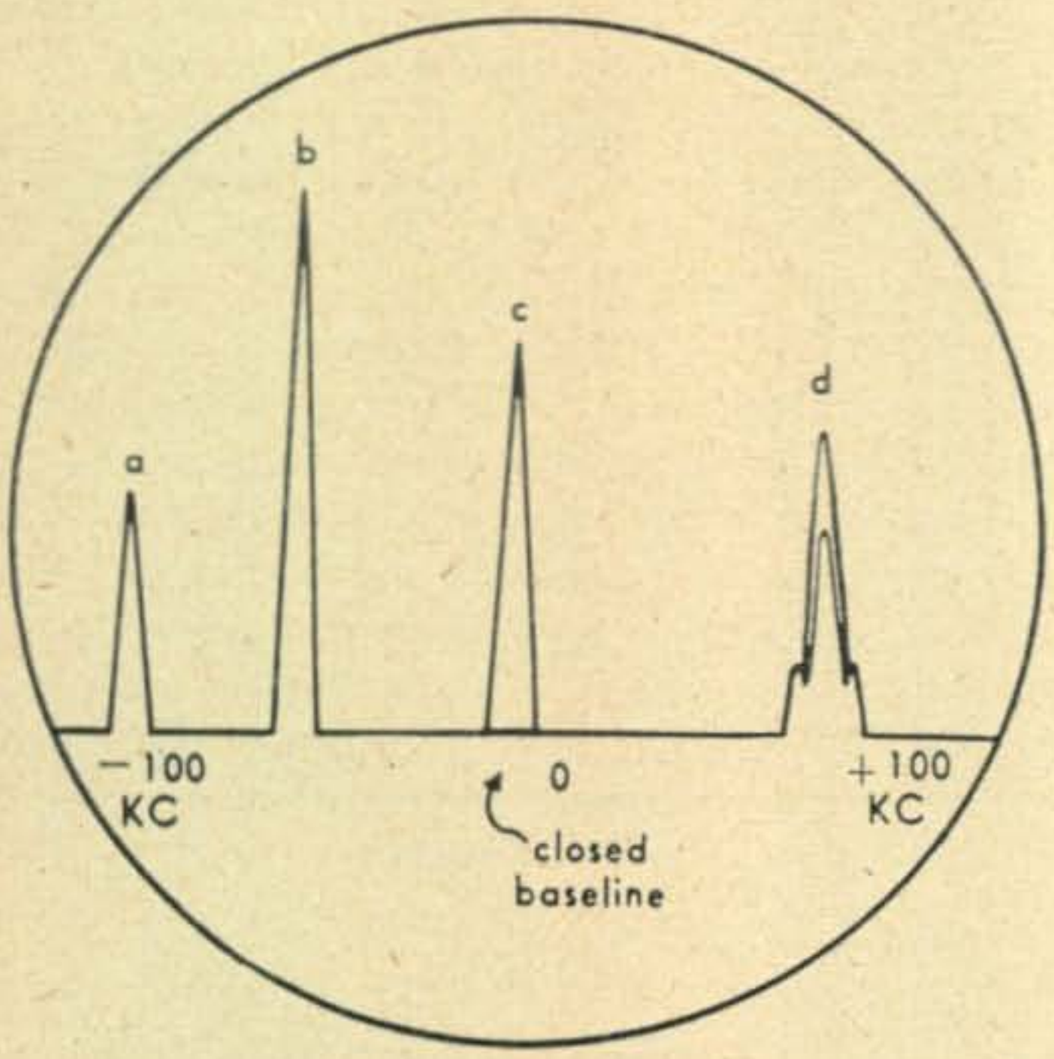


Fig. 1. Four signals appearing simultaneously on the Panoramic screen. Only station (c) will be heard on the receiver

of a cathode-ray tube are indicative of the presence of signals. The character of each individual deflection tells its own story.

Interpreting the Screen

1. In *Fig. 1*, (a) is a signal of constant amplitude indicating a steady carrier. The height of the peak shows that (a) compared with (b) or (c) is a weaker signal than the others.
2. Signal (b) is a non-varying signal the strength of which is about twice as great as that of (a).
3. In *Fig. 1*, (c) is a peak which appears and disappears so rapidly that the baseline appears closed beneath the deflection. This type of deflection is produced by a very rapidly keyed c.w. signal. For slower keying, the baseline will appear open and the c.w. signal may be read directly from the screen (*with practice*).
4. Peak (d) is composed of separate parts. The smaller peaks are produced by the sidebands of the modulated carrier. The high center peak represents the carrier itself. Hence, this is a picture of a phone station. More often, the sidebands will not be visible as separate deflections, a phone station being recognizable by a tendency to "bob" up and down between the center peak and the lower center peak.

In addition, the various frequencies shown may be compared with reference to each other, or with reference to the receiver tuning dial. As an illustration (still with *Fig. 1*), let us imagine that the *receiver dial* reads 5,000 kc. Signal (c), the c.w. station discussed above, appears immediately above the zero on the scale. This scale reading indicates that the frequency of the signal (c) is that indicated on the dial of the receiver, or 5,000 kc.

Another way of saying the same thing is that the frequency difference between the receiver dial reading and the signal appearing over the center scale marking, is zero. It follows from this that signal (a) is 100 kc lower than signal (c) or 4,900 kc; and signal (d) is approximately 80 kc higher than signal (c) or 5,080 kc. Hence, while

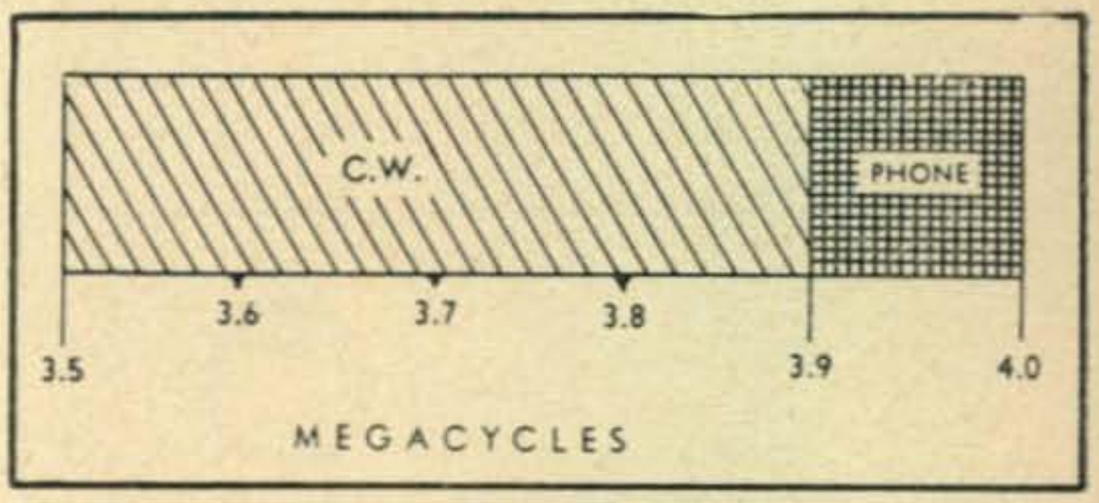


Figure 2

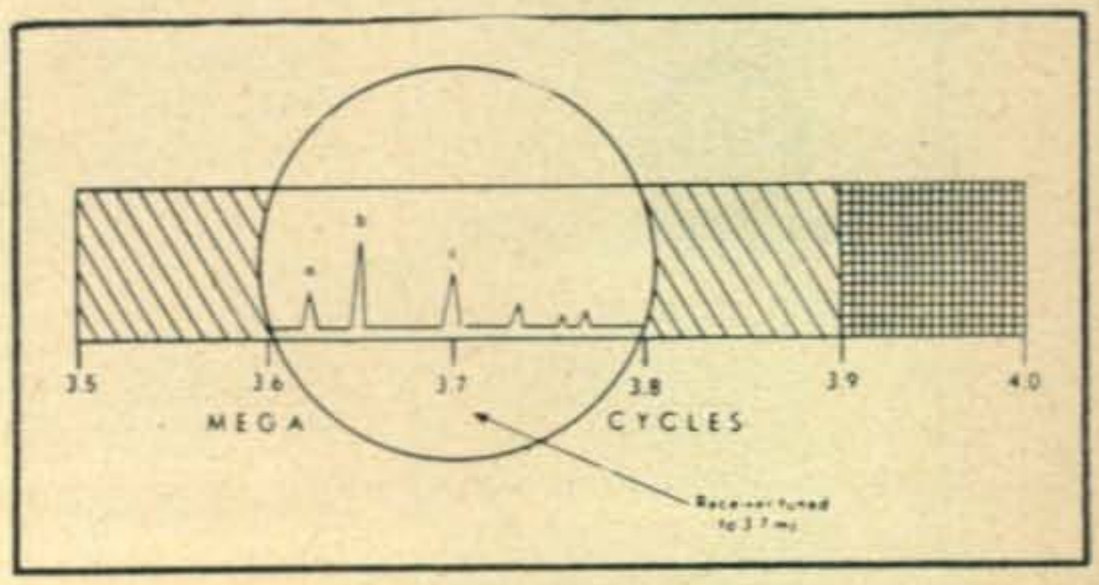


Figure 3

RECEPTION

HARVEY POLLACK, W2HDL

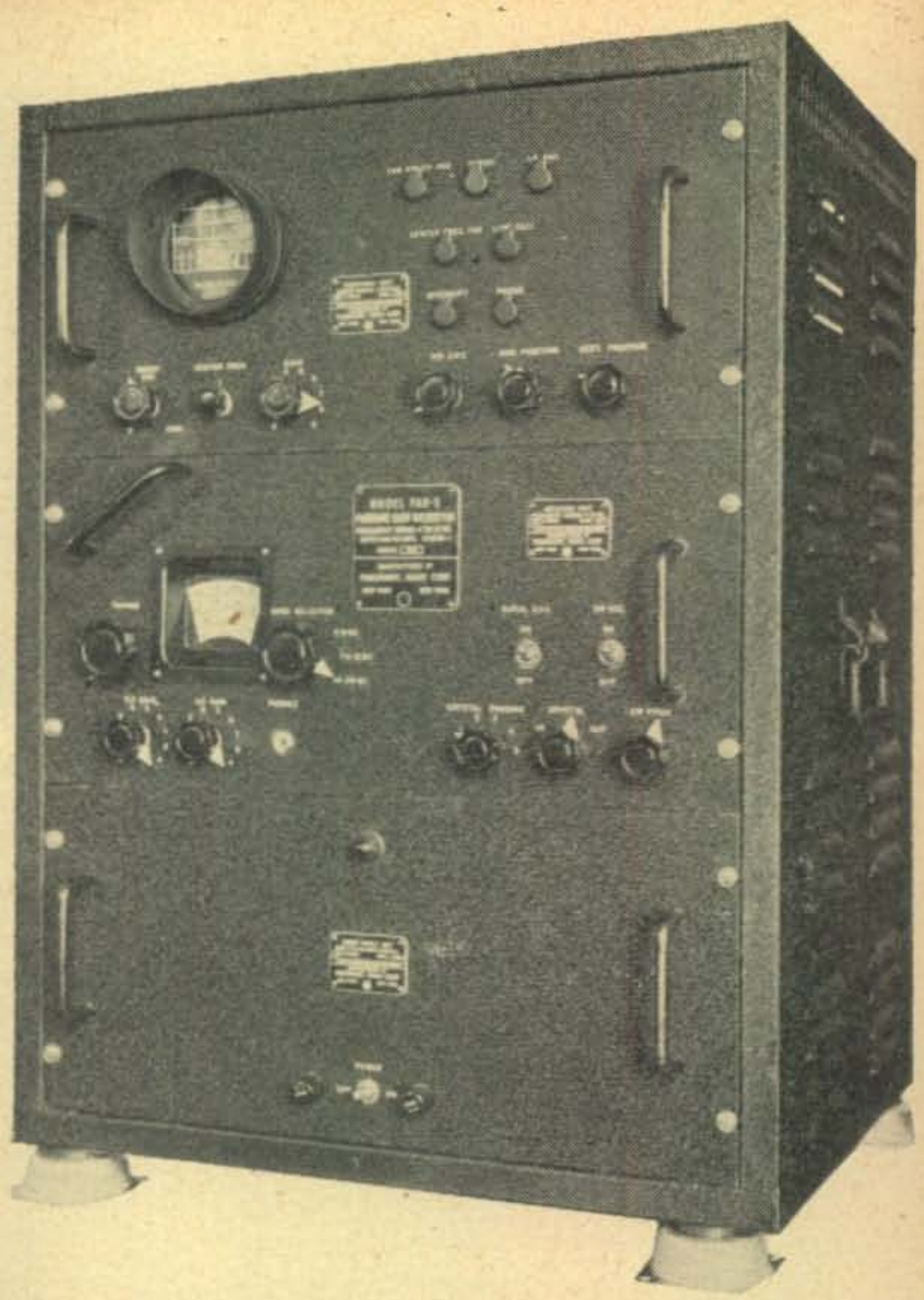


Fig. 18. As the military like it—the Panadaptor combined with receiver for the Army and Navy

only signal (c) is heard on the receiver, the other signals will be seen distributed as shown on the diagram.

Panoramic Tuning

Let us choose the 3.5 mc (80-meter) amateur band for our discussion. This band extends from 3.5 mc to 4.0 mc and is shown graphically in *Fig. 2*. Assuming that your receiver has been equipped with a Panadaptor of 200-kc bandwidth and is tuned to 3.7 megacycles, all the signals between 3.6 and 3.8 mc will be visible on the Panadaptor screen (*Fig. 3*). The signal (c) heard on the receiver will of course appear at the center of the screen. Should you wish to listen to the signal (a), the receiver would have to be tuned to a lower frequency. As the receiver is shifted, all the peaks will move to the right across the screen until the signal (2) is heard in the phones. At that moment, it will appear centered (*Fig. 4*). Signal (c) has now moved to the right of the screen and is visible but no longer audible; (b) has passed center and was probably heard for an instant while tuning through; and (a) is now audible and centered. At the same time, signals (d), (e) and (f) that were not present previously have now made an appearance at the left side of the screen.

Since the signals in the example are all c.w., the images will appear and disappear with the keying. Should you now tune to the phone band, the signals will appear as peaks pulsating in amplitude (as already explained) due to modulation.

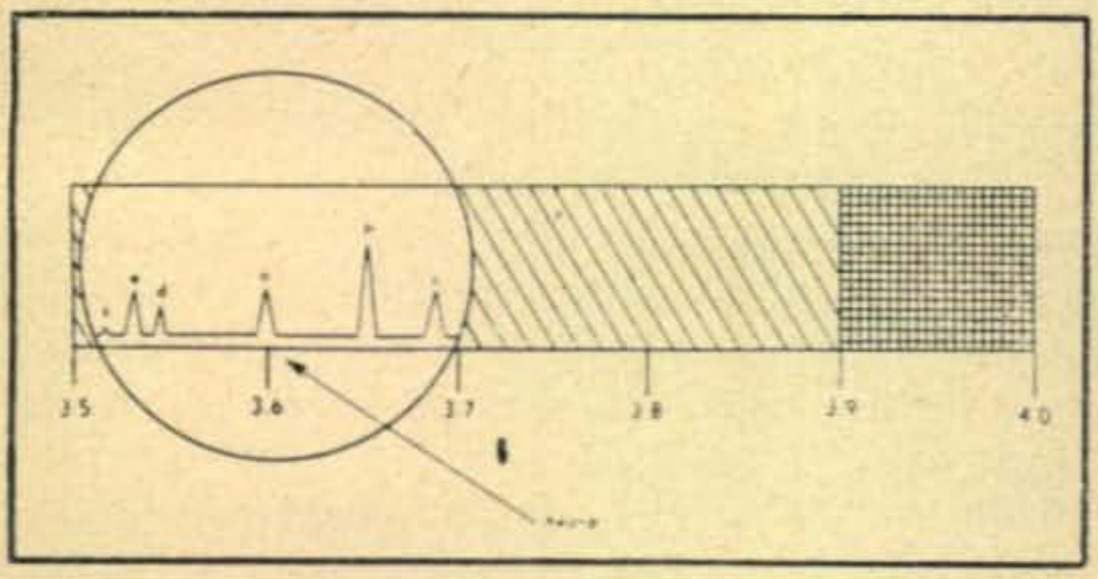


Figure 4

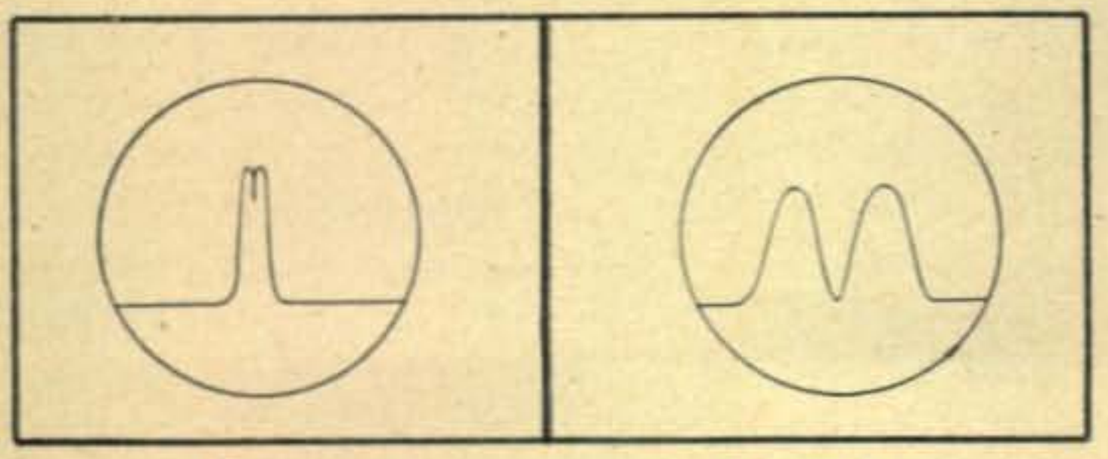


Figure 5

Figure 6

Connecting the Panadaptor

Some of the finer amateur communications receivers are manufactured with a Panoramic connector already installed. With such receivers, it is only necessary to connect the adaptor cable between "PAN" on the receiver and the input connector on the adaptor. If no connector is provided, it is quite simple to make the necessary connections. Solder a ½-watt isolating resistor, either 25,000 ohms or 50,000 ohms (depending on

Figs. 2, 3 and 4. Panoramic reception as applied to the amateur 3.5 to 4.0-megacycle band

Figs. 5 and 6. Visual selectivity control with Panoramic reception is variable and compares with the crystal filter in a standard communications receiver

Fig. 14. The Hallicrafters' "Super Skyrider" with a built-in Panadaptor

the Panadaptor model) to the plate pin of the converter (first-detector-mixer) tube socket. Anchor the other end of the resistor to the chassis by means of a sturdy, insulated lug. Connect the inner conductor of the coaxial cable supplied with the Panadaptor to the anchored end of the resistor and solder the coaxial sheath either directly to the chassis or to a strong, grounded solder lug. Secure the connector at the other end of the cable to the PAN connector, or input, of the adaptor. This procedure is applicable to all standard pre-war communications receivers having one, two, or no r-f stages of pre-selection.

Variable Visual Bandwidth

The preceding discussion has been based upon the use of the full sweep of the Panadaptor—that is, the particular model discussed is capable of providing a maximum visual bandwidth (or sweepwidth) of 200 kilocycles. The number of kc visible at any time, however, is under the direct control of the operator and may be reduced gradually all the way down to zero, if so desired. The value of this control cannot be over-emphasized, because it provides the operator with a "visual vernier" of the most flexible variety. As the sweepwidth is reduced, the resolution constantly improves. The term "resolution" is used here in the same sense as the word "selectivity" is employed in discussing the frequency discrimination of receivers. It is really "visual selectivity." Screenings *Figs. 5* and *6* illustrate this point. Two signals differing in frequency by say, 3 kc, would present the appearance shown in *Fig. 5* if the sweepwidth control of the adaptor is set at its maximum position. However as this control is backed off, the signals separate and, at about 20% of maximum, will appear somewhat as presented in *Fig. 6*. The increase in visual selectivity may be carried still further by a greater reduction in sweepwidth. This feature permits visual inspection and analysis of interfering and heterodyning signals. If you should be in the middle of a QSO when QRM starts to wash it out, a quick reduction in sweepwidth will disclose the side (high or low frequency) where the heterodyne modulation is taking place. A break-in flash such as, "QSY 2 or 3 kc higher," should restore your QSO to a clearer channel. Just as a crystal filter or a variable selectivity i-f control on an ordinary receiver is employed when the congestion in the band warrants it, the variable sweepwidth feature of the Panadaptor meets the problem of visual interference with great effectiveness.

Different Maximum Sweepwidths

One of the first questions to arise during an introduction to the Panoramic technique is "how many kilocycles can I see at once?" Ask yourself the analogous question along photographic lines—"How wide an angle will this lens cover?" In the first place you will buy that lens or Panadaptor which suits a special purpose. If you desire good resolution and fine detail, you will want a narrow angle lens, and, in our analogy, an adaptor with a small bandwidth. On the other hand, if your purpose is to obtain a "panorama" without too much emphasis on magnification of specific small portions of the radio frequency spectrum, then an adaptor having a 1 to 3-mc sweepwidth is suitable. It must be remembered, however—and this is important—that the tuning range and intermediate frequency of your receiver dictate what the upper limit of sweepwidth will be in an adaptor chosen to operate with it. For example, it would be technically impractical to obtain a sweepwidth of 3 megacycles with a 455-kc intermediate frequency.

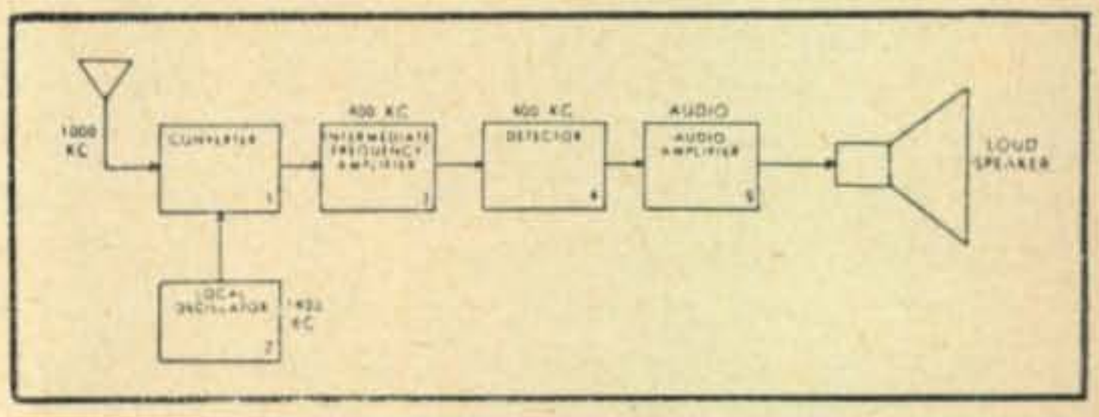


Fig. 7. Block diagram of the conventional superheterodyne

How the Panadaptor Works

For the benefit of those who have permitted themselves to become rusty in elementary radio theory, let us first review the principle of operation of an ordinary superheterodyne receiver. Assume that a 1,000-kc signal is to be received. Referring to *Fig. 7*, the 1,000-kc signal is fed to a tuned stage called the converter (1). At the same time, an oscillator (2) feeds a signal of 1,400 kc into the converter. When these signals of

different frequency "mix" with each other, a new frequency, representing the difference between the two original frequencies, appears. In this case, the difference frequency or "intermediate frequency" is 400 kc. The original frequencies are still present plus a fourth frequency, the sum of the originals, but the tuning of the next stage (3) is so sharp that only the 400-kc signal is permitted passage and amplification. Following intermediate frequency amplification, the signal is detected or demodulated (4), the modulation being amplified through (5) to a sufficiently high level to operate the speaker. We might then list:

Signal frequency—1,000 kc
Oscillator frequency—1,400 kc
Intermediate frequency (i.f.)—400 kc

To tune a station on 1,300 kc, the tuning condenser knob is rotated to the new position. In

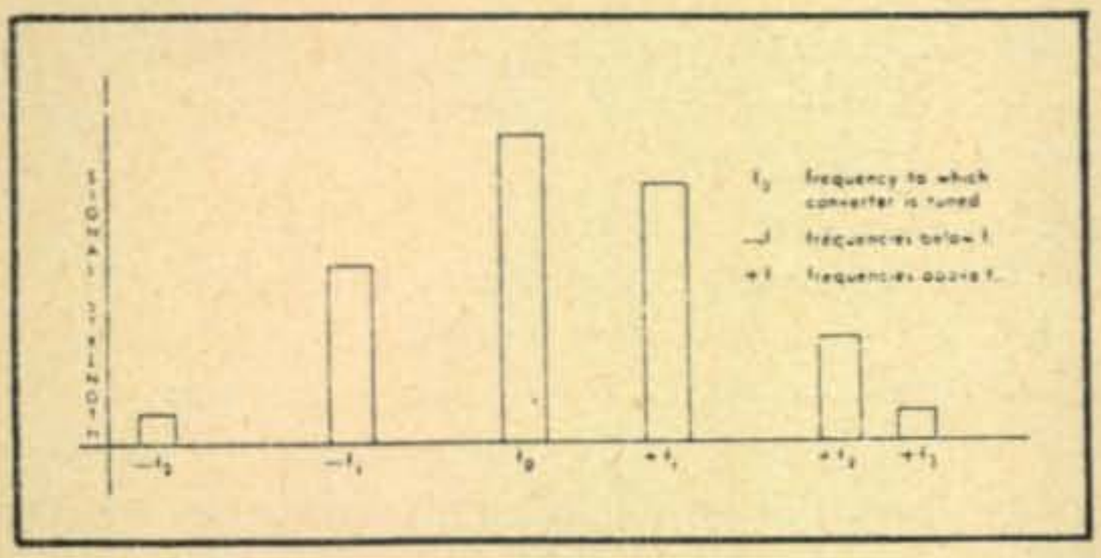


Fig. 8. Off-resonance signal attenuation in a typical converter stage

so doing, we have changed both the converter and the oscillator frequencies as follows—

Signal frequency—1,300 kc
Oscillator frequency—1,700 kc

However, the 400-kc i.f. has not changed because we have maintained a constant difference between the signal frequency and the oscillator frequency. Thus, the i-f amplifier is adjusted to resonate permanently at 400 kc. By means of two tuned stages (1) and (2) we can obtain a higher degree of selectivity than was ever practical with the old t-r-f receivers. This is the major advantage of the superheterodyne.

Adding a Panadaptor

Again referring to *Fig. 7*, it is obvious that many hundreds of signals of different frequencies

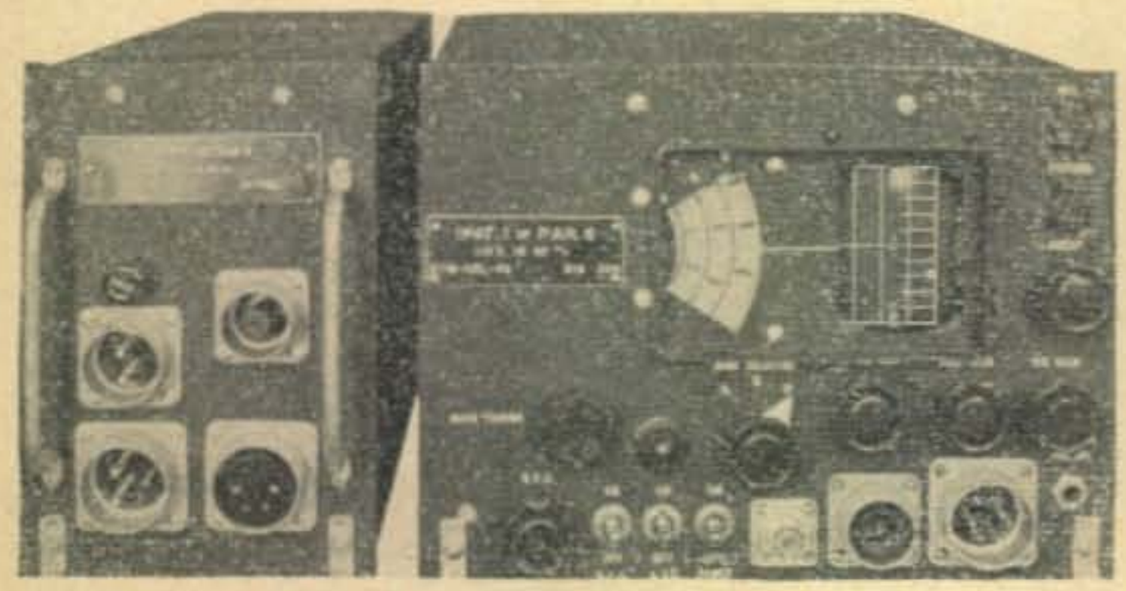


Fig. 17. An Army version of the Panadaptor

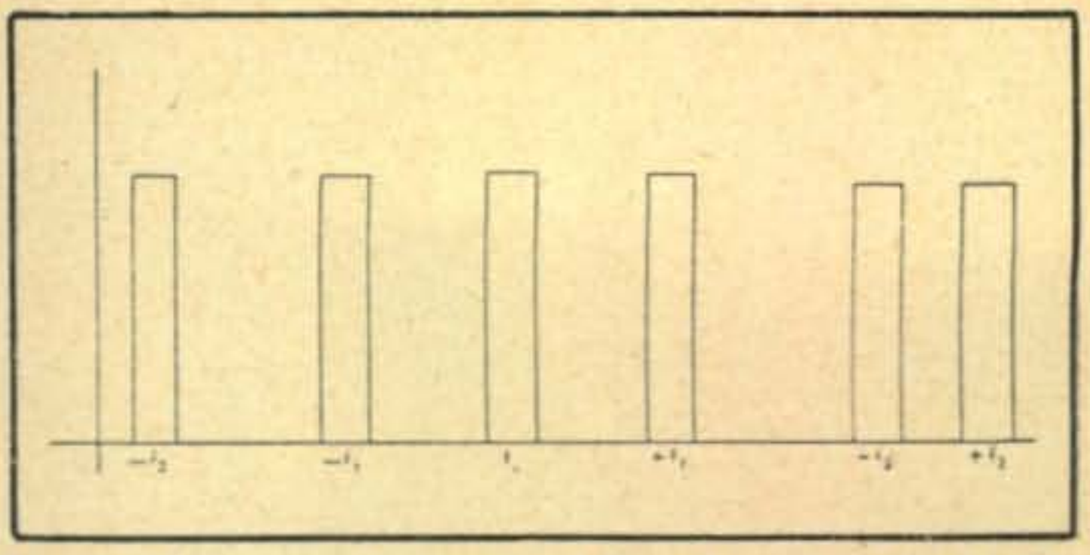


Fig. 9. The unequal signals of Fig. 8 are levelled off in the amplifier of the Panadaptor

are inducing their respective voltages in the antenna. Although the converter stage contains a resonant (tuned) circuit, its selectivity is so poor that signals differing by several hundreds of kilocycles from the one to which it is tuned are present within the tube and its associated circuits. Starting with the assumption that 6 signals of equal strength reach the antenna, the signal to which the converter is tuned will be the strongest, while the others (off resonance) will fall off in some proportion to their frequency separation from the center (*Fig. 8*).

The presence of these signals makes it possible to receive all of them simultaneously, without interference or confusion, by means of Panoramic Reception. With reference to *Fig. 8*, if the receiver converter is tuned to 1000 kc, and the amplitude (strength) of the received signal f_0 has the value shown, other frequencies above and below f_0 will suffer attenuation somewhat as illustrated. The frequency range between $-f_2$ and $+f_3$ might be, for example, 200 kc. So much for the receiver.

A small part of each of these dissimilar signals is now injected into the first radio-frequency amplifier of the Panadaptor. This stage is so designed that the unequal amplitudes as shown in *Fig. 8* will emerge from it almost levelled-off, resulting in the picture illustrated in *Fig. 9* Using the values assumed previously, f_0 having a frequency of 1000 kc would produce an i.f. of 400 kc when mixed with an oscillator frequency of 1400 kilocycles. Assuming the other frequencies arbitrarily, we may draw up the following table—

	Sig. Freq.	*Rec. Osc. Freq.*	*i.f.*
$-f_2$	900 kc	1400 kc	500 kc
$-f_1$	960 kc	1400 kc	440 kc
$-f_0$	1000 kc	1400 kc	400 kc
$+f_1$	1025 kc	1400 kc	375 kc
$+f_2$	1075 kc	1400 kc	325 kc
$+f_3$	1100 kc	1400 kc	300 kc

Thus, only f_0 is reproduced in the loudspeaker since the highly selective i-f amplifier tuned to the 400-kc intermediate frequency produced by f_0 will reject the spurious frequencies. But, the small portion of each of these signals which is fed to the special radio-frequency amplifier of the

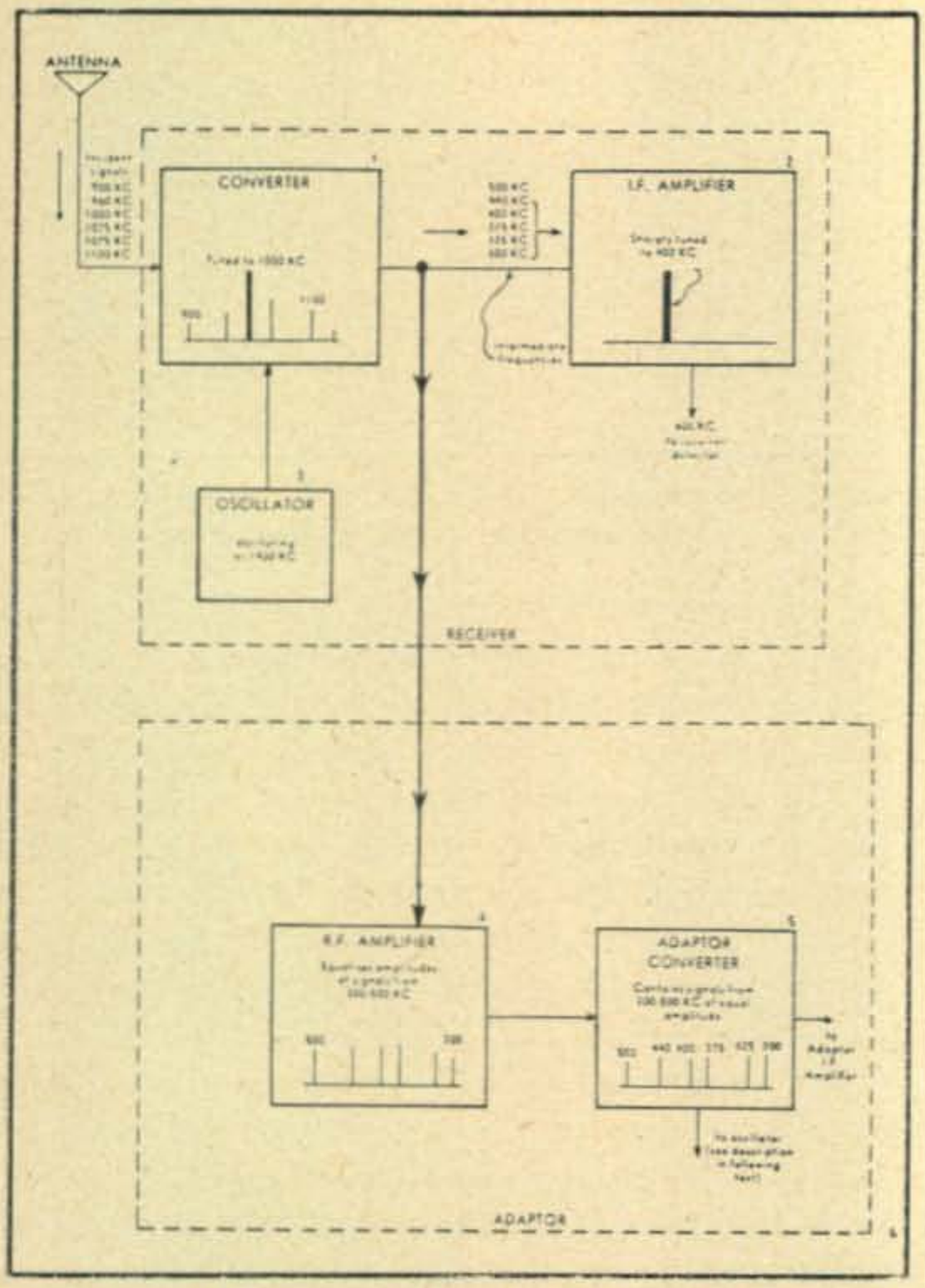


Fig. 10. Block diagram showing relative signal strengths in different portions of the receiver and Panadaptor

adaptor, reaches the converter of the adaptor in the form shown in *Fig. 9*. The block diagram (*Fig. 10*) summarizes what we have said thus far.

FM Oscillator

Let us now assume that the adaptor converter is followed by a sharply tuned i.f. amplifier resonated to 200 kc and that an oscillator injects a 600-kc signal into the adaptor converter. Obviously, only the 400-kc signal will produce an i.f. of 200 kilocycles with an oscillator frequency of 600 kc. If we rotate the oscillator tuning condenser so that its frequency changes back and forth (or "sweeps") continuously between 700 and 500 kc, it will mix with one after another of the signals shown in Block 5, *Fig. 10*, and produce for each signal an i.f. of 200 kc. For further clarification, study the following table—

Signal in (Block 5) Adaptor-Converter	*Osc. Freq. to Produce an i.f. of 200 kc*
300 kc	500 kc
325 kc	525 kc
375 kc	575 kc
400 kc	600 kc
440 kc	640 kc
500 kc	700 kc

(Range of adaptor oscillator variation is from 500 kc to 700 kc)

At one time or another during the "sweeping" of the oscillator by rotation of its tuning dial from 500 to 700 kc the oscillator frequency will be just right to produce an i.f. of 200 kc to which the adaptor intermediate-frequency amplifier is resonant. Thus, one after another, the signals in the adaptor-converter passes through and are amplified by the i-f amplifier. (It should be understood, however, that the oscillator sweep in the Panadaptor is accomplished electronically rather than manually.) The problem now arises as to the speed at which the oscillator frequency is to vary. Let us call this variation speed the *sweep rate*. If, for example, the oscillator reaches a frequency of 700 kc once each second, during the same second it will have passed through 500 kc, 550 kc, 555 kc, etc., and is said to have a sweep rate of 1 cycle per second. For reasons that will be apparent later on, we shall choose a sweep rate of 30 cycles-per-second. (The electronic method used to accomplish oscillator sweep will not be detailed here since it is beyond the scope of this article.) This means that during every 1/30 second, the oscillator produces an intermediate frequency of 200 kc with each of the signals present in the converter.

One at a time, these signal pulses are fed to a detector and amplifier, appearing as a voltage at the output of the latter. Each signal then follows the other until, within 1/30th second, every one of them has created its own voltage for an instant.

The Cathode Ray Indicator

As we have said, Panoramic Reception is *visual* reception—by means of a trace on a cathode-ray tube screen. Since our space is too

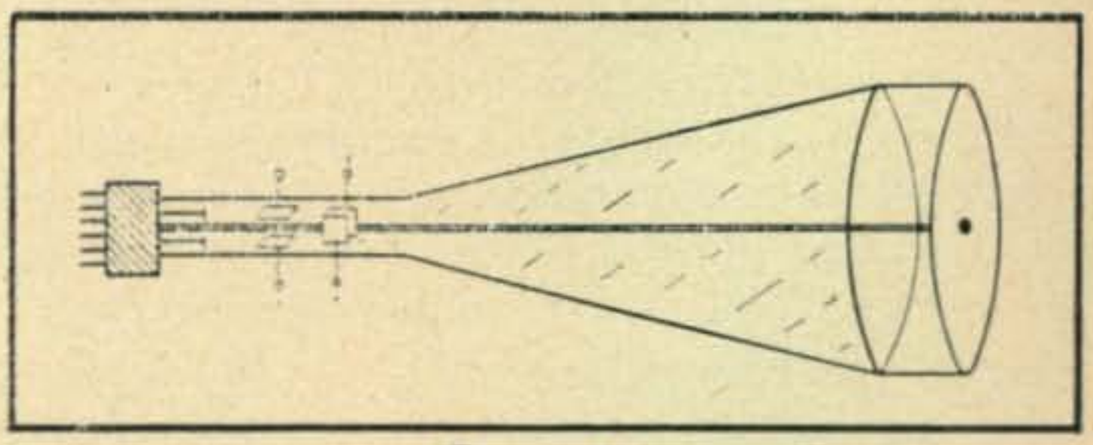


Figure 11

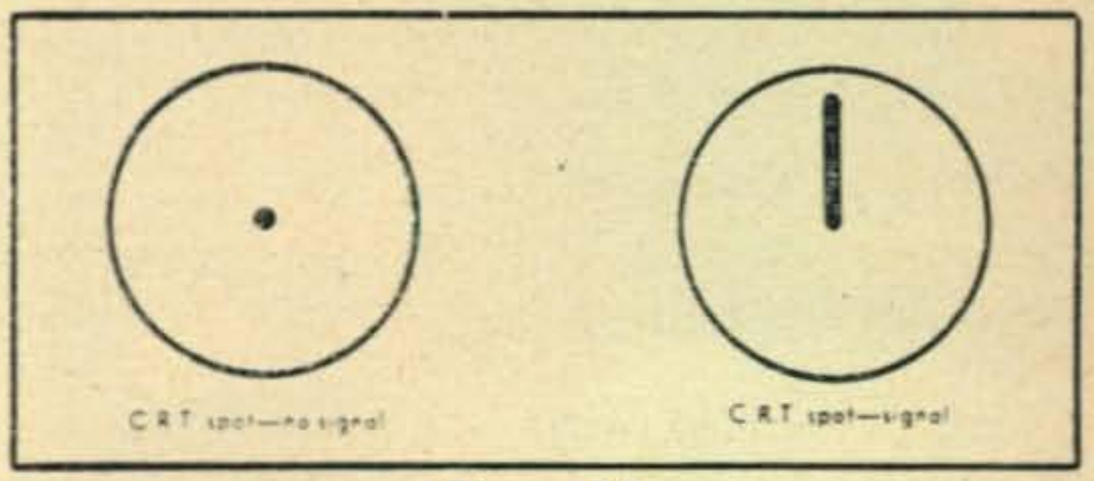


Figure 12

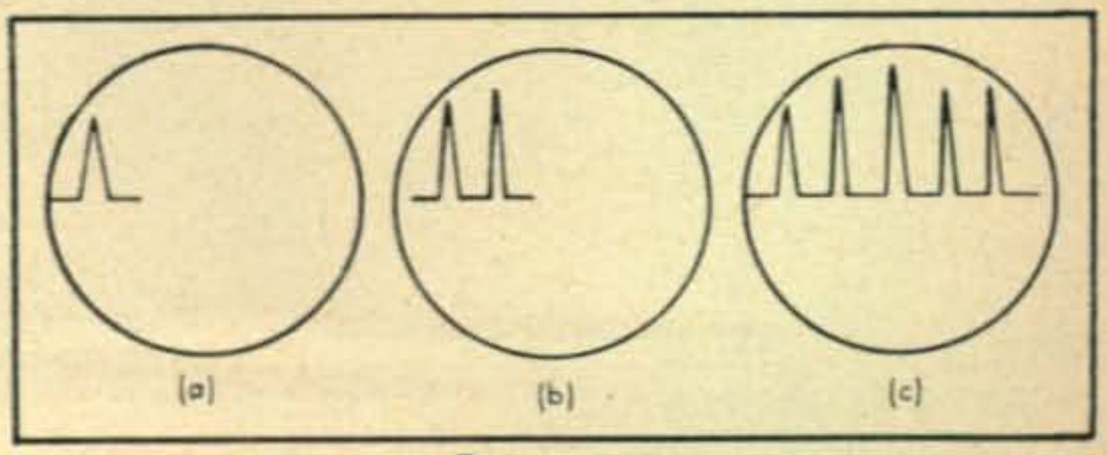


Figure 13

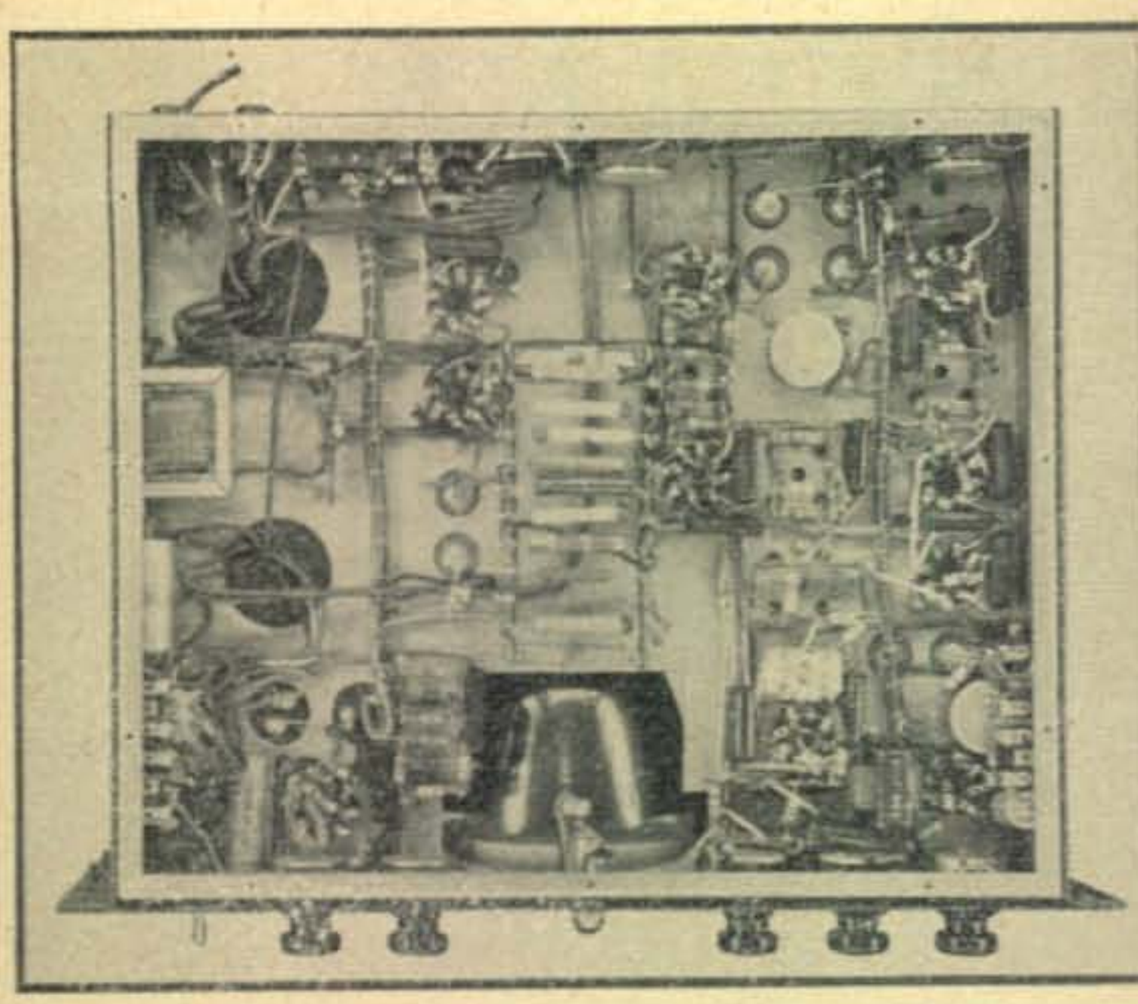


Fig. 15. Worm's eye view of the Panadaptor—which can also be used as an S-meter, and for measurement of distortion and percentage modulation

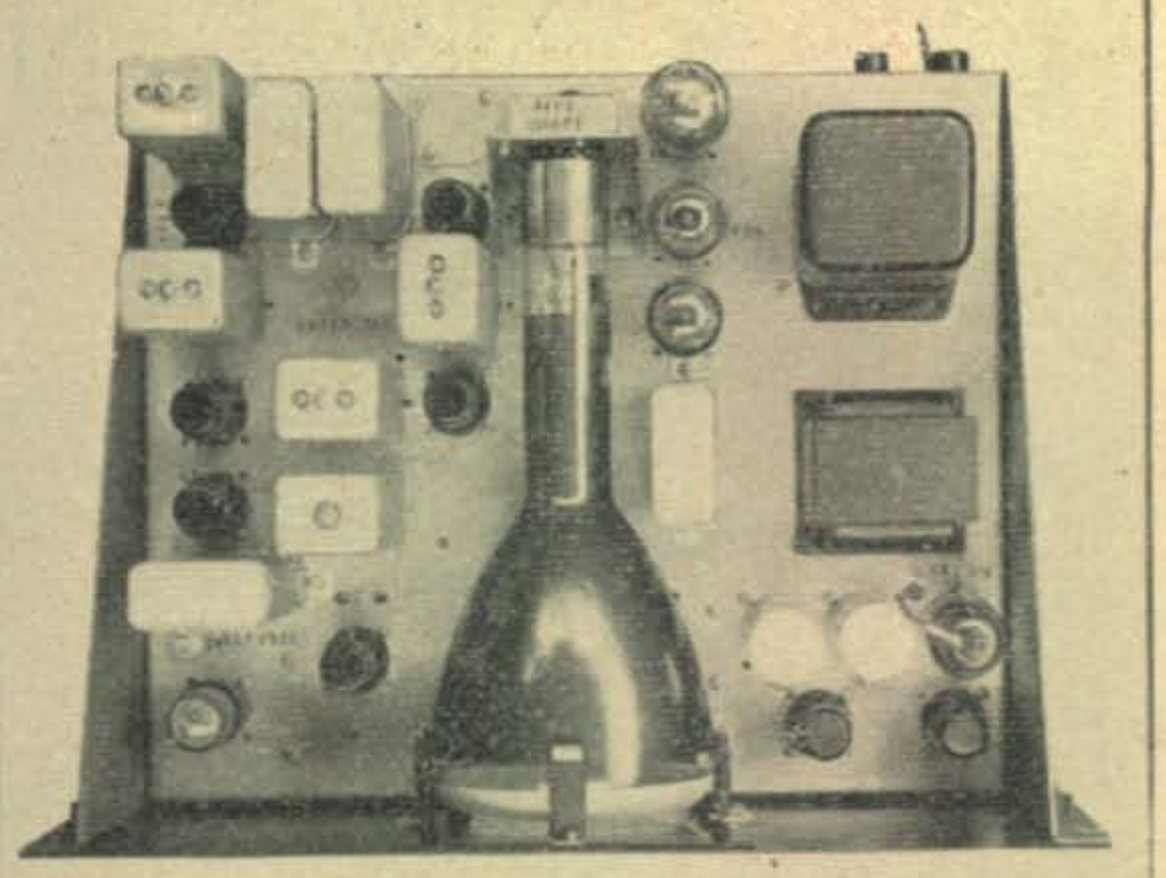


Fig. 16. The Panadaptor as seen from the top. This equipment appears to be a must in the up-to-date post-war station

limited for an extended explanation of the C.R.T., we shall confine our discussion to the more applicable portions of its operation.

A stream of electrons emitted from a hot cathode at one end of the tube is focussed on a fluorescent screen at the other end, appearing as a bright green spot on the screen. Two parallel sets of metal plates surround the stream (*Fig. 11*), and, when an appropriate voltage is applied to them, the beam is deflected so that it traces a line across the screen. An alternating potential applied to terminals 1 and 2 will cause a vertical line to appear on the screen in place of the spot, while the same voltage applied across terminals 3 and 4 will produce a horizontal line. Therefore, 1 and 2 are called the vertical deflecting plates and 3 and 4 the horizontal deflecting plates.

The output of the detector-amplifier combination is applied to the vertical deflecting plates. Consider what happens to the spot during 1/30 of a second. Assuming signals of equal strength, the first signal to pass the adaptor i.f. causes the spot to jump upward and trace a vertical line, returning immediately to the center position (*Fig. 12*). The next signal, coming on the heels of the first, will do the same. The process is repeated until every signal present in the adaptor has produced its own vertical line. All this happens so rapidly (1/30th second) that due to the persistence of vision and the retentivity of fluorescence, the line seems to remain on the screen as long as signals are fed to the detector.

Fig. 11. The familiar voltage-deflected cathode-ray tube

Fig. 12. Looking at the screen from the front, with no voltage (left), and with vertical deflection

Fig. 13. Showing step-by-step signal build-up when the horizontal sweep is applied

Sweep Action

The horizontal sweep action involves the use of an alternating voltage the frequency of which may for the moment be considered 30 cycles—providing a *sweep rate* of 30 cycles per second. This alternating potential is applied to the horizontal deflecting plates of the C.R.T. producing a horizontal deflection at the same time that the signals are tracing vertical lines.

Thus, if the spot is moved to the right side of the screen by the alternating voltage at the instant the 500-kc signal of our example appears at the vertical plates, the result will be somewhat as shown in *Fig. 13* (a). This deflection is open at the bottom because some time elapses while the spot moves up and down during the simultaneous horizontal motion. An instant later, the 440-kc signal produces a vertical deflection, but by this time the spot has moved to the right and the picture is that of (b). The first deflection is still visible due to persistence of vision and retentivity of fluorescence. Following rapidly are the other signals which produce the composite result shown in *Fig. 13* (c). Remember that each peak exists only for a small portion of the total time, but all peaks *appear* to be present simultaneously.

Each peak will be of the same size only because we started with the assumption of equal signal strengths. Had the signal amplitudes differed from each other, the peaks would vary proportionately. Note that the peak due to the 400-kc intermediate frequency is at the center of the screen. This peak is, therefore, the reproduction of the original 1000 kc signal to which the receiver is tuned. It is clear that the signal *heard* will appear centered on the screen, while the operator will be able to *see* all other signals within a

[*Continued on page 36*]

TELEVISION SCANNING

B. W. SOUTHWELL, W60JW

Television will doubtless play a large part in post-war ham radio. Television is no longer the simple art it was in the days of mechanical scanning. It is a science all its own, and here are a few of the fundamentals.

IN ORDER TO TRANSMIT and receive intelligible visual images it is necessary that the subject picture focussed on the mosaic of the iconoscope be scanned very rapidly so that a complete picture can be transmitted in a fraction of a second. It is also essential that the image be reproduced on the fluorescent screen of the kinescope exactly as it was seen by the iconoscope.

Three views of the fluorescent screen of a cathode ray tube are shown in *Fig. 1*. In *A*, with no connections to the deflection plates, the electron beam striking the screen appears in the center, midway between the horizontal deflecting plates *1* and *2*, and vertical deflecting plates *3* and *4*. If a potential is connected across the tube between plates *1* and *2*, the beam, which consists of negative particles of electricity, will move horizontally toward the positively-charged plate *2*, as indicated in *Fig. 1B*. Similarly, the beam can be displaced vertically upward as in *Fig. 1C*.

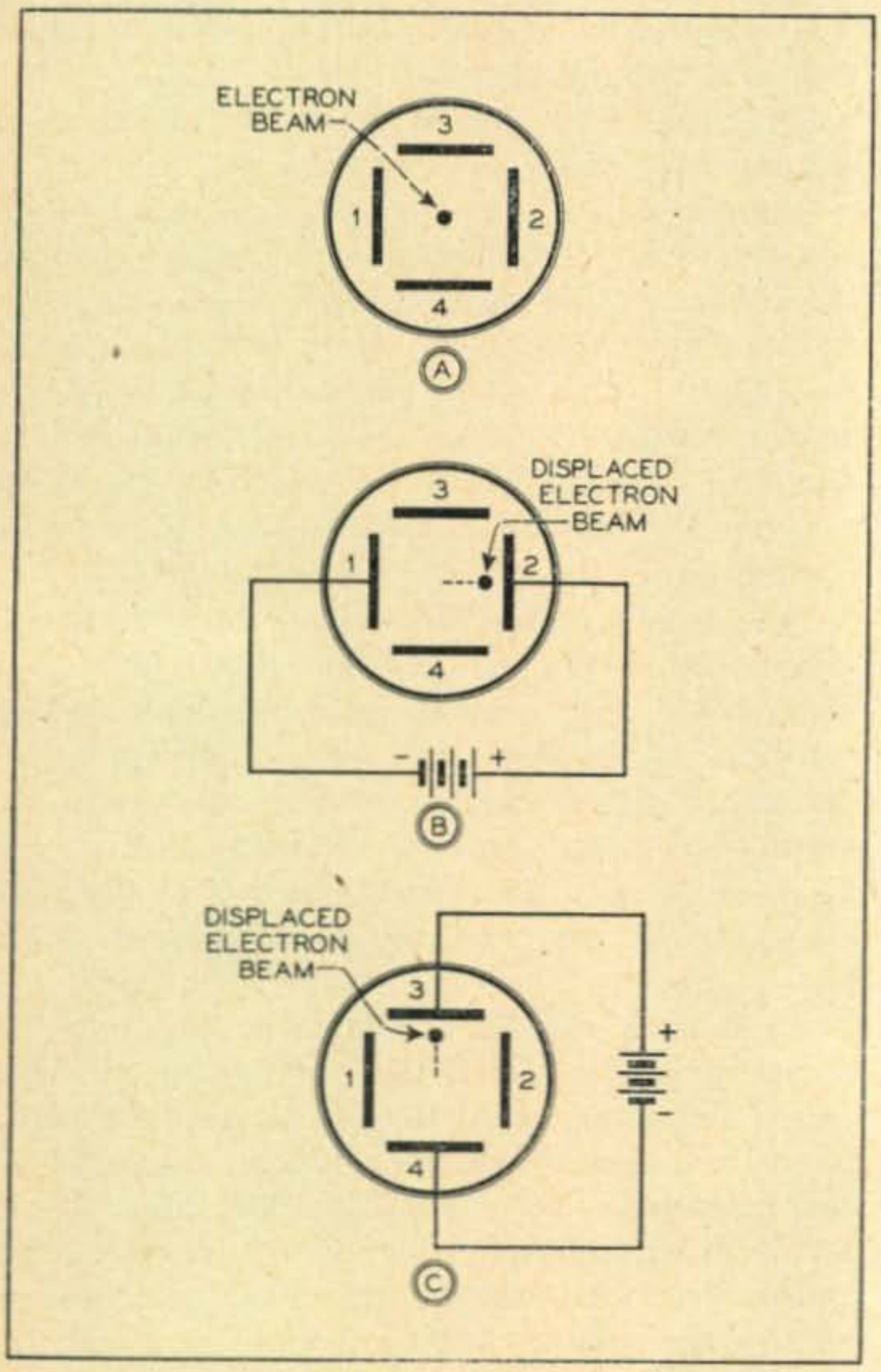


Fig. 1. Showing how the electron beam or "spot" is deflected in a cathode ray tube. A combination of rapid horizontal and vertical displacements build up the "picture"

If the battery voltage is replaced by an oscillating or alternating potential on the horizontal plates, the beam will sweep back and forth across the screen. The length of this sweep will depend on the voltage applied. An alternating potential applied to the vertical plates will cause the spot to move up and down between plates *3* and *4*.

Sawtooth Scanning

In scanning an image it is necessary that the deflection increase linearly in respect to time. In other words, the voltage must build up linearly while the beam sweeps across the face of the screen and then reverse itself and decrease rapidly to its initial value. The waveform of the voltage produced in the output of scanning generators appears as shown in *Fig. 2*, and is known as a "sawtooth" wave.

There are two types of cathode ray tubes—the electrostatic-deflecting and magnetic-deflecting. In the electrostatic-deflecting design the outputs of the scanning generators are fed to two sets of deflecting plates. One pair sweeps the beam horizontally and the other pair vertically. In the magnetic deflecting type deflection is accomplished by varying the magnetic field between two sets of coils placed at right angles to each other around the neck of the tube

AND SYNCHRONIZATION

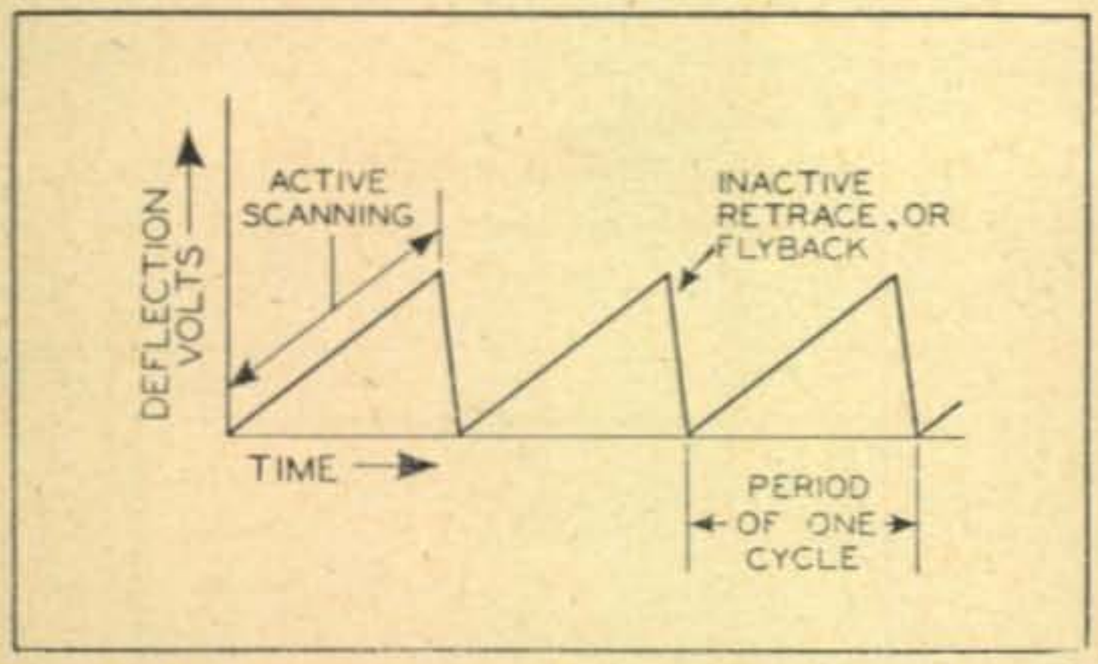


Fig. 2. The "sawtooth" of a scanning generator. In conventional 525-line television the horizontal period is 1/15,750th of a second

just beyond the last anode in the electron gun. The magnetic field of one set tends to move the beam back and forth in a horizontal direction (horizontal sweep coils) and the other vertically (vertical sweep coils). The sawtooth waves produced in the scanning generator for electrostatic deflection are voltage waves, while those generated for magnetic deflection are sawtooth waves of current.

If an alternating sawtooth potential of 15,750 cycles per second is applied to the horizontal deflection plates, and a sawtooth voltage of 60 cycles to the vertical plates, the beam will sweep back and forth across the screen 15,750 times a second and up and down 60 times per second. The resultant reproduced picture on the fluorescent screen of the cathode ray tube is a scanning "raster" consisting of 525 lines.

Sawtooth Generators

There are various types of sawtooth generators. One of these employs a two-element gaseous discharge tube. Such a tube contains two electrodes immersed in a gas at low pressure and is connected across the terminals of a capacitor. This type is of little value for television purposes due to the fact that it cannot be accurately synchronized.

The scanning generator most commonly used is a conventional three-element vacuum tube, which is free from temperature and de-ionization delay effects. This type of scanning generator, employing the multivibrator principle, is shown in *Fig. 3*. The multivibrator pulse generator circuit is very similar to that of a regular resistance-coupled amplifier. The circuit requires two triodes which are generally included in one envelope. The output of the second triode is fed back to the grid of the first triode in the right phase to sustain oscillations. By varying the grid condenser C and the grid-resistance R, it is possible to change the fundamental frequency of the multivibrator. This arrangement is very popular as it is easy to synchronize.

The blocking oscillator type of scanning generator; illustrated in *Fig. 4* is a later development and is also reliable and simple to adjust. The oscillations are blocked suddenly when the grid is driven negative by the passage of grid current, and commence again as the charge flows off through the gridleak. A separate triode, (which in practice is generally the other half of a twin-triode type tube) is used to discharge the capacitor C. The frequency at which the blocking oscillator operates is determined by the RC combination RgCg. As Rg decreases in value, the charge leaks off Cg faster and the blocking action repeats itself at a higher rate.

Sawtooth oscillators which are not blocking oscillators are generally termed "relaxation" oscillators. Relaxation oscillators are divided into two types, the symmetrical and the un-

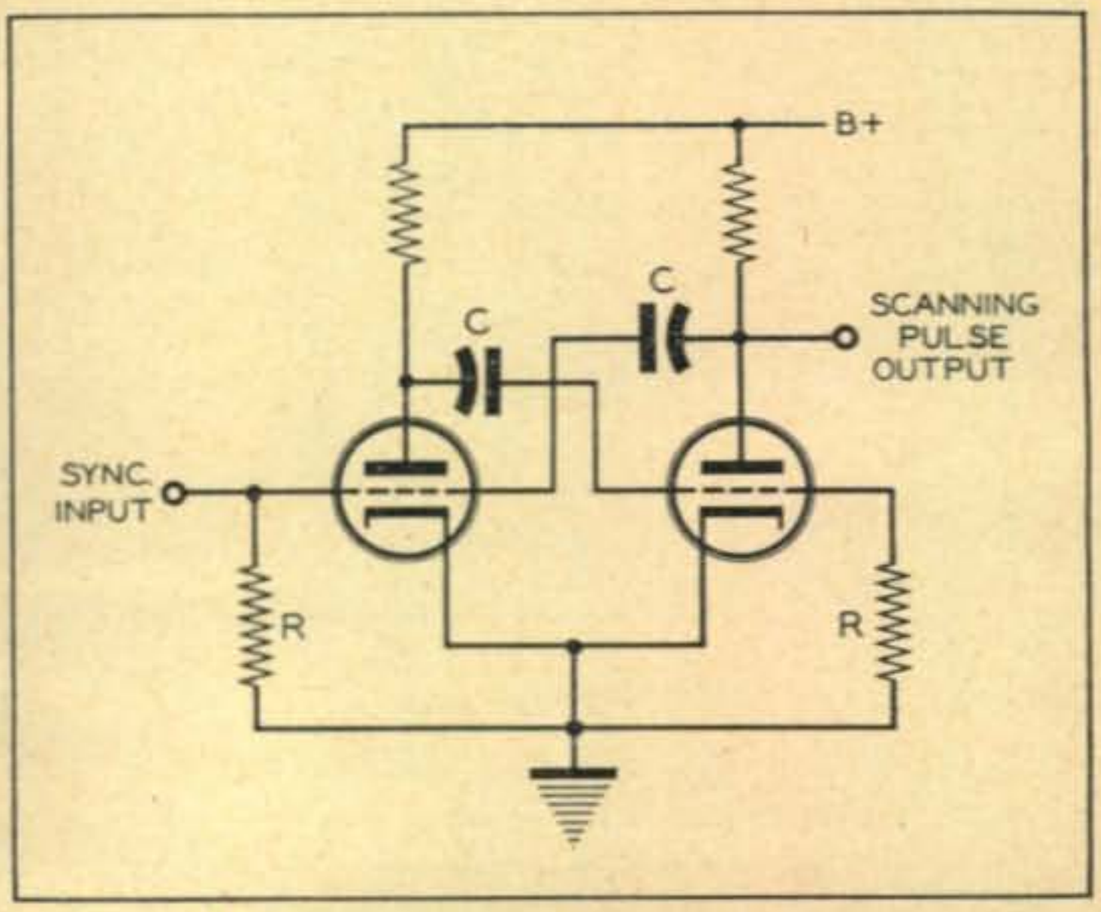


Fig. 3. Multivibrator type of sawtooth wave generator

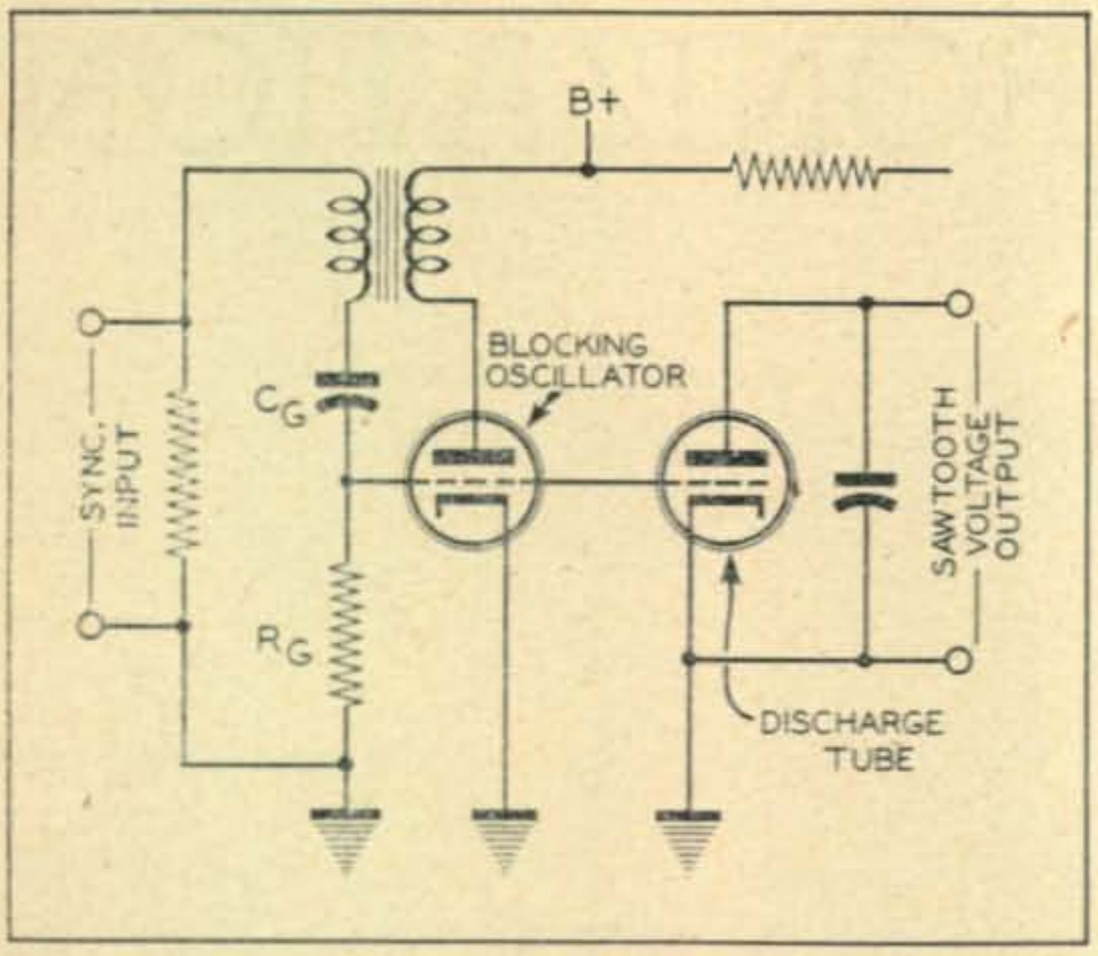


Fig. 4. Blocking oscillator generator with discharge tube

symmetrical. In the symmetrical type, a voltage wave is generated with a quick "flip-over" from extreme negative to extreme positive values, followed by a period during which the voltage decreases slowly (relaxation), until the critical value is reached and the process repeats itself in the opposite direction. The unsymmetrical oscillator generates positive and negative waves of unequal magnitude and duration. The waveforms of these two types as viewed on a test oscilloscope, are shown in *Fig. 5*.

The frequency of horizontal scanning generators to reproduce an image of a certain number of lines is derived from the formula

$$\text{Lines} = 2 \text{ X } \frac{\text{horizontal frequency}}{\text{vertical frequency}}$$

For example, a 525-line image will require a horizontal oscillator frequency of 15,750 cycles (assuming a 60-cycle vertical sweep).

When construction of a television receiver is contemplated, it will be desirable to consider separate power supplies for the horizontal and

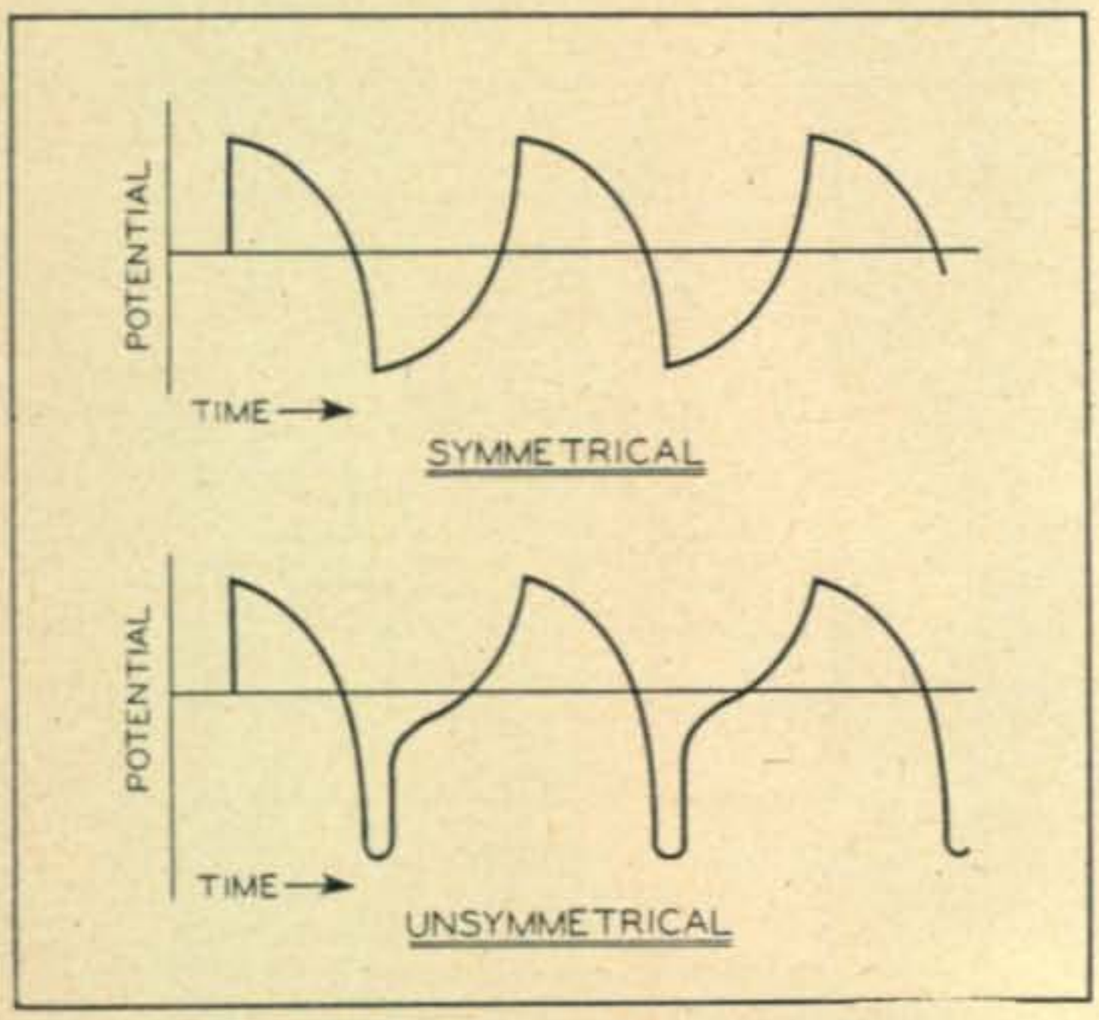


Fig. 5. Relaxation oscillator waveforms

vertical scanning generators to minimize cross-talk. When vertical deflection intermingles with the horizontal, the pattern shape is distorted. Harmonics of the horizontal sawtooth appearing in the vertical deflection circuits cause the scanning lines to become wavy instead of straight.

Scanning Methods

There are various methods of scanning and reproducing an image by an electron beam, the best known of which are the progressive (non-interlaced) and the interlaced (preferable method). The progressive system consists of a picture scanned by a single set of parallel, adjacent lines, as shown in *Fig. 6A*. The solid lines are the scanning or active lines, while the broken lines are the return or inactive lines. The inactive lines are blanked out so that they do not

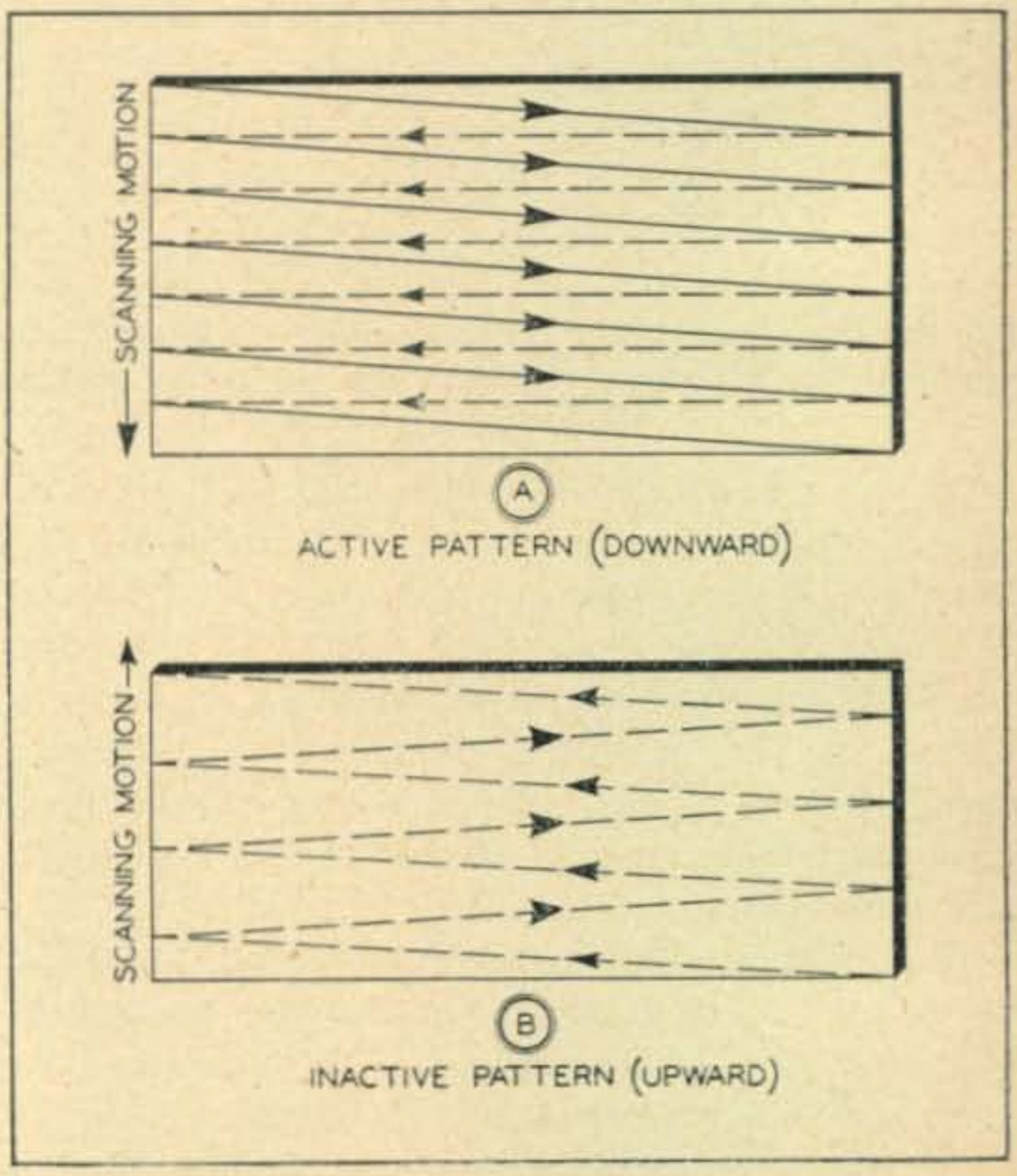


Fig. 6. Progressive scanning patterns. Inactive or return sweeps are dotted

appear in the reproduced image. The electron beam is moved back across the picture instantaneously during the time of the inactive lines. At the completion of an inactive line the horizontal blanking action ceases and the beam starts to trace another active line slightly below the preceeding line. The distance one line lies below the preceeding one depends primarily on the frequency of the horizontal scanning generator, and the coordinated action of the vertical oscillator on the beam to bring the spot down to the start of the next line. The higher the frequency, the greater the number of scanning lines and consequently each line is closer to the preceeding one. Similarly, if the frequency is low the number of lines is smaller and hence the lines are spread out from each other. The downward ac-

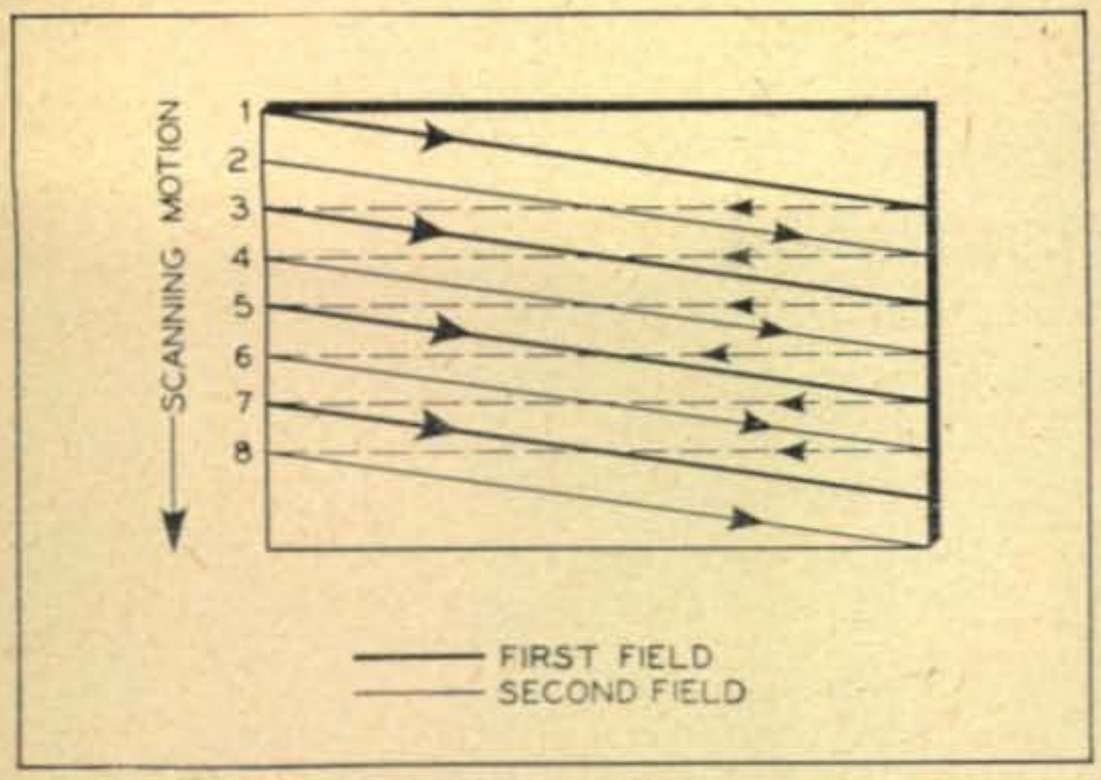


Fig. 7. Odd-line interlacing. Return or inactive lines are dotted. Vertical return is shown on the right

tion of the vertical oscillator is constant during the time of the active scanning line and the blanked-out retrace. One can readily see that if the retrace were not instantaneous horizontal dark lines or bands would run through the picture.

At the end of the last scanning line, *vertical* blanking is imposed on the spot, extinguishing and returning it to the upper left corner of the picture. This return is fast compared with the downward motion and the line moves back and forth several times as shown in *Fig. 6B* (inactive pattern). These upward motions constitute the difference between the active lines and the total number of lines of the entire pattern. The number of inactive (upward) lines must be kept to a minimum. In practice, the number of vertical inactive lines is 41 or less.

Each scanning line should be just thick enough to be adjacent to the preceeding one and must equal the distance between centers of adjacent lines. The line thickness is derived from the formula

$$\text{Thickness} = \frac{\text{height}}{\text{number of active lines}}$$

For a 525 line picture with 483 active lines and a height of six inches, the line thickness will be 6 divided by 483 or .0124 inches.

Interlaced Scanning

The interlaced method of scanning is a different story. The lines are scanned in the order 1, 3, 5, 7, etc., followed by 2, 4, 6, 8, etc. The time for covering the picture area is reduced from $\frac{1}{30}$th to $\frac{1}{60}$th second so that in the first field in which the odd numbered lines are scanned, the spacing between lines (center to center) is doubled. The second field in which the even numbered lines are scanned must fall accurately so that the lines of the second field are half-way between the lines of the first field. The interlaced pattern is shown in *Fig. 7*.

There are two methods of interlacing—the odd-line and even-line systems. In the odd-line method the total number of lines is an odd number. It is simpler than the even-line system and is the method most commonly used. In the even-line method (*Fig. 8*) the total number of lines is an even number. The difficulty lies in accurately forming up and down motions of unequal length in the required succession. Since it is superseded by the odd-line system we shall not discuss it further.

With odd-line interlacing, there are 262.5 lines in each successive field. Every up and down motion must be precisely the same length in order that interlacing be preserved. At the start of each field, in order to avoid "pairing," the spot must be one-half line distant and exactly on the same level as the start of the previous field. (Pairing will be described later.)

There are other methods of scanning in less general use. Sinusoidal scanning uses simple deflection circuits, which are relatively free from distortion as well as inexpensive. Spiral scanning makes maximum use of a circular cathode ray screen, but is wasteful of screen area in rectangular pictures. Like sinusoidal scanning it is difficult to synchronize. Another method is velocity scanning which produces brighter high lights and needs no synchronization. Its principle is brightness inversely proportional to scanning velocity, but requires an excessive vertical blanking period.

In interlacing, the simple two to one is the easiest form to obtain and is employed in the odd-line system. While greater detail is available with a higher ratio interlace, it is difficult to syn-

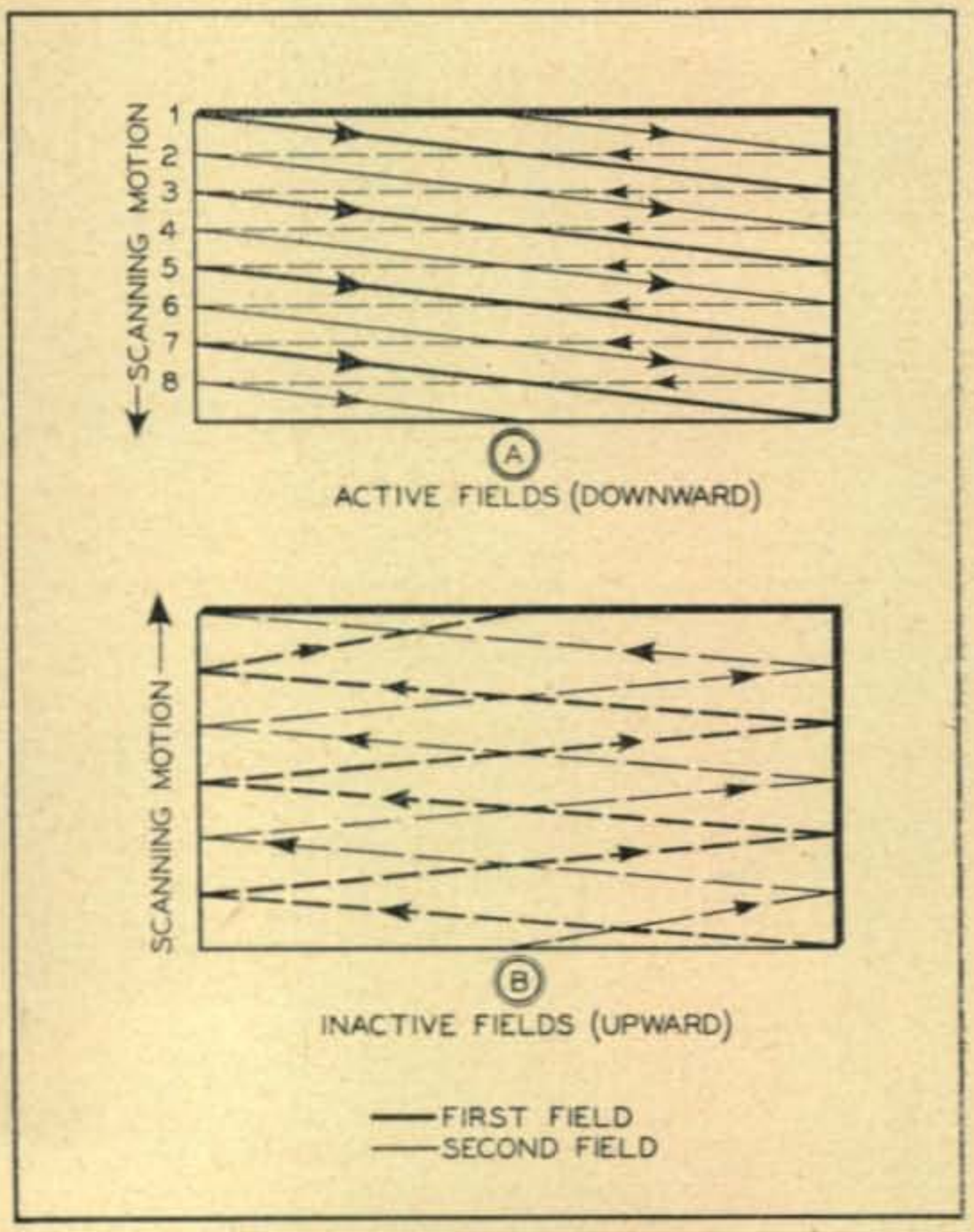


Fig. 8. Even-line interlacing

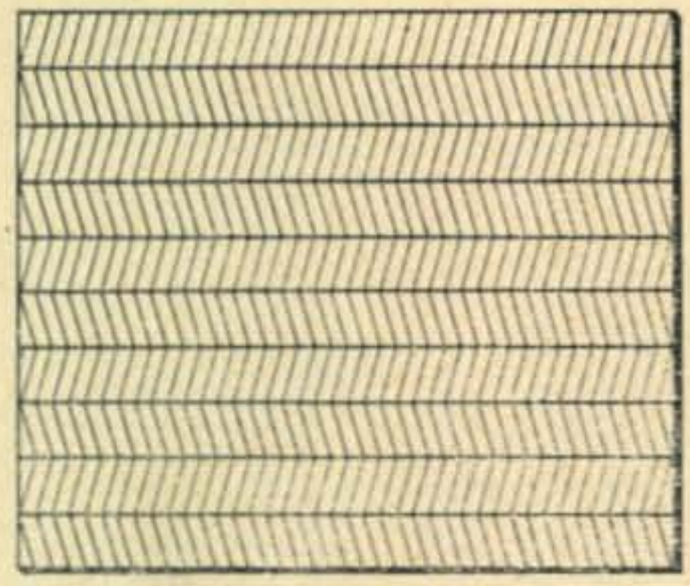


Fig. 9. Showing "pairing" of lines in successive fields due to improper timing of vertical scanning generator

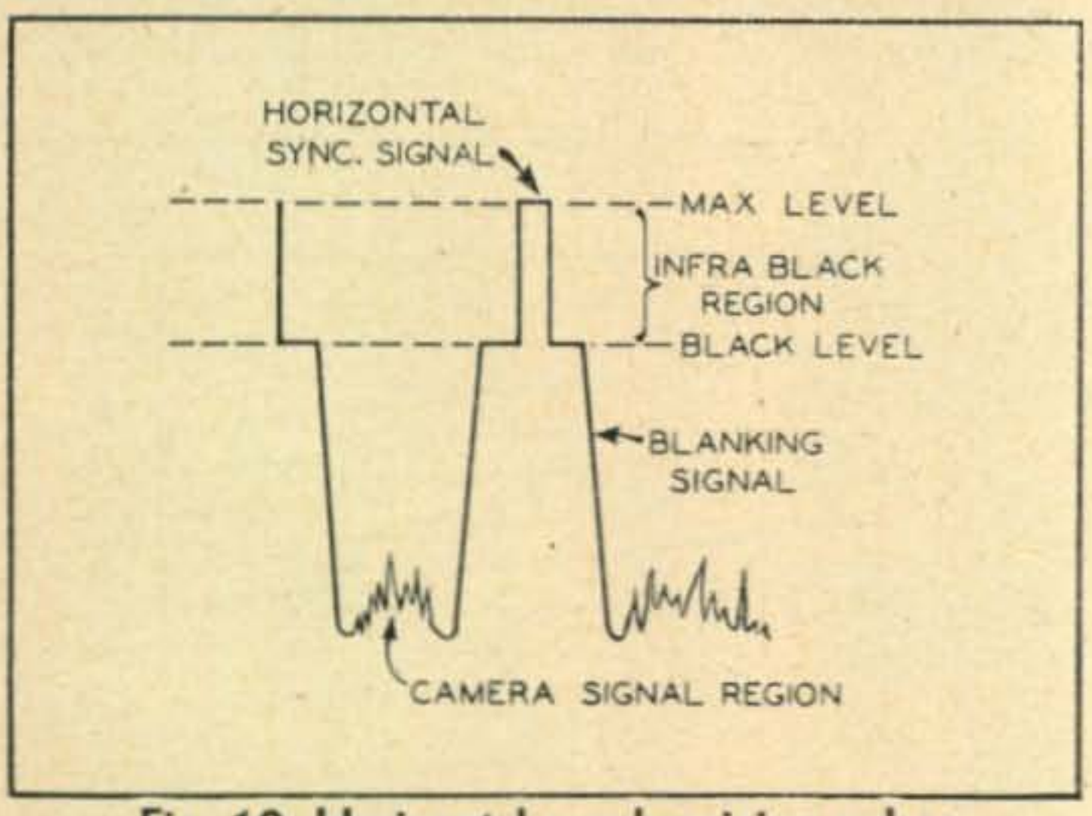


Fig. 10. Horizontal synchronizing pulses

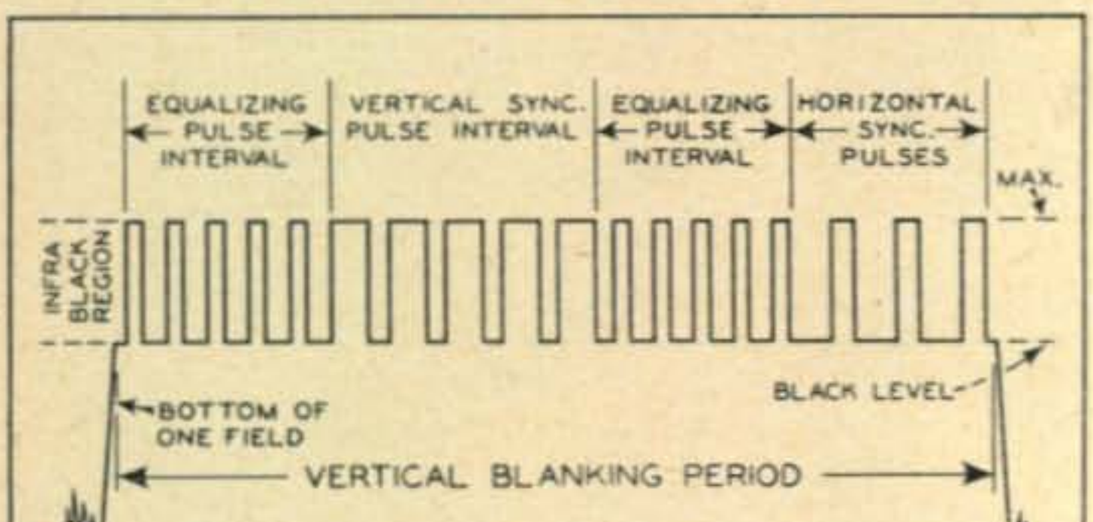


Fig. 11. Vertical synchronizing pulses

chronize accurately to avoid pairing, and interline flicker becomes apparent due to lower frequency.

Synchronization

The method by which the electron beam in the receiver is kept in step with the scanning beam in the inconoscope at the transmitting position is called synchronization—or familiarly "sync." The synchronizing signal is applied between the grid circuit and the ground of each scanning generator.

If, in each scanning cycle, the timing is not the same as the preceeding cycle, the picture elements in the cathode ray tube will be displaced in the reproduced image. The picture elements in one line are displaced to one side or the other, relative to the next line, if the horizontal synchronization is faulty. On the other hand, if the vertical scanning synchronization is out of step, lines in one interlaced field will be displaced vertically with reference to lines of the preceeding field. The lack of vertical sync will cause what is known as "pairing," as shown in *Fig. 9*. There are two important frequencies in synchronizing:

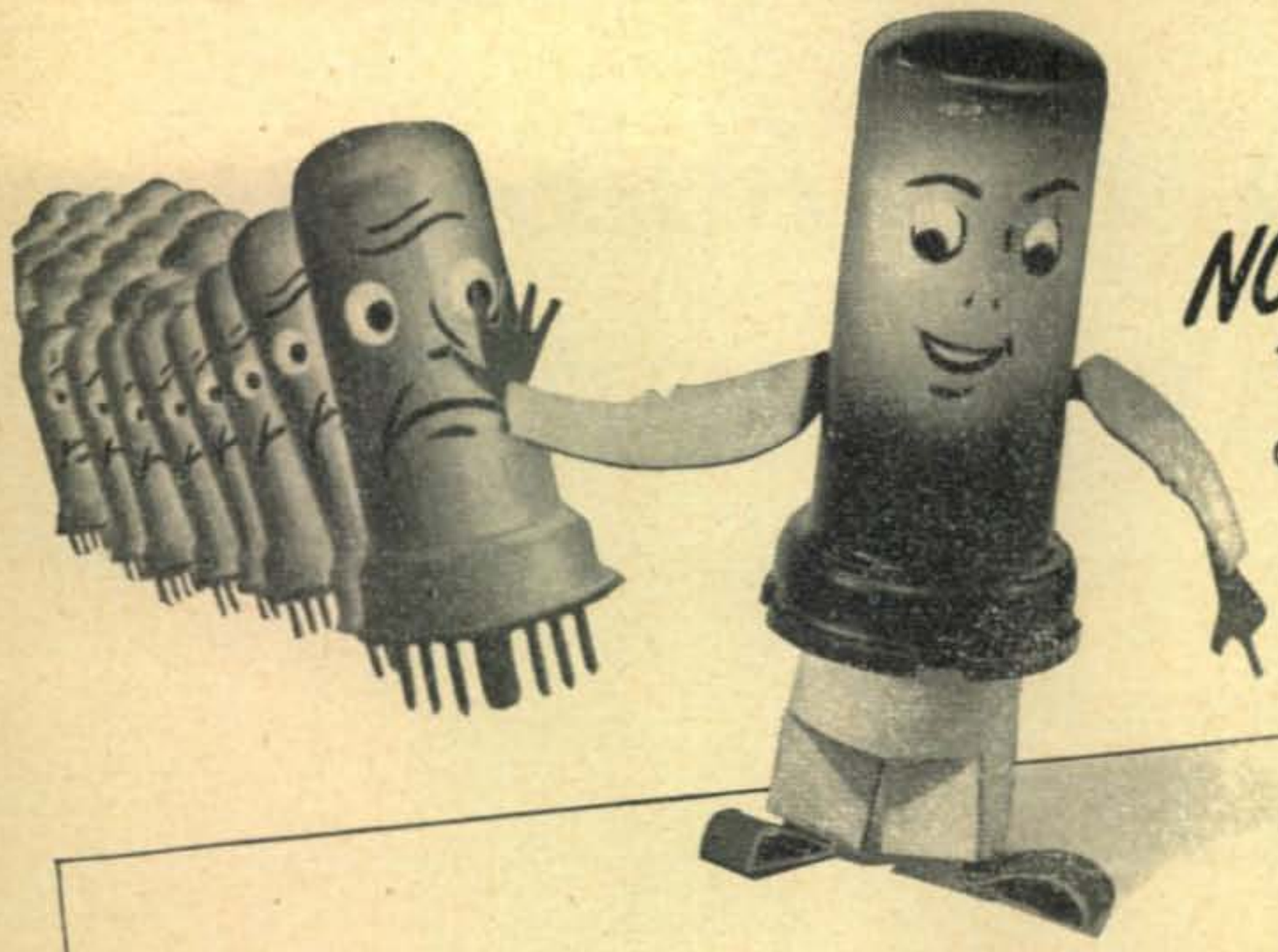
1—The free or natural frequency of the scanning generator itself which is governed by the constants of the circuit (resistance and capacitance values, tube constants, etc.).

2—The synchronizing frequency, which is the frequency of pulses applied to the grid of the scanning generator tube.

When the sync pulse is approximately the same frequency as the free frequency, the scanning generator then operates at a forced frequency, which is equal to the sync frequency whenever an image is being reproduced. Viewed on a test oscilloscope the sync pulse appears to be riding on the top of the horizontal blanking pulse as in *Fig. 10*. It is not desirable to have the sync frequency and the free frequency exactly the same. The general rule is, to set the free frequency far enough below the sync frequency so that they cannot become equal, but not so far as to cause the sync circuit to lose control. If the free frequency were set above the sync frequency the period between pulses occur during the time a line is being scanned. Setting the free frequency below shortens the period between pulses, and the oscillator is held back continuously because the sync pulses always appear at the end of the scanning of each line.

Horizontal pulses occur at the end of each line and "lock in" each of the successive transmitted lines. These are sharp, nearly rectangular pulses (see *Fig. 10*) which occur 15,750 times per second for a 525 line picture. For every 262½ horizontal

[*Continued on page 34*]



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No. 4. RECEIVER ANTI-NOISE CIRCUITS

MANY RADIO RECEIVERS for point to point applications do not receive signals continuously but are used in a standby or monitoring condition for appreciable periods of time. In many cases the transmitter is switched off during the standby period but sometimes both transmitter and receiver remain operative at all times. If the carrier is transmitted only during the operating period and drops to zero at other times, the receiver may receive sufficient noise and static to be a major annoyance. This is particularly true if the radio receiver employs automatic volume control. In this case the sensitivity of the receiver is controlled by the incoming signal carrier during the operating period but once the carrier is cut off the receiver sensitivity increases to maximum.

In ordinary broadcast short wave receivers, the same situation results when the receiver is tuned from one weak signal to another. When one signal is tuned out, the carrier vanishes and the receiver sensitivity is increased by the automatic volume control to maximum, where it remains until a new station is tuned in.

To remedy this situation a number of anti-noise or noise reducing circuits have been devised. These circuits may be limiters of various sorts of circuits which render the audio circuits inoperative during the periods when no carrier is being received. One of the first circuits of this sort consisted of a carrier rectifier which operated a d-c relay. The relay contacts were frequently used to insert sufficient bias in an audio circuit to render it inoperative, to short the headphones or loud-speaker, or to open the output circuit at some convenient point. Such a circuit is shown in *Fig. 1*. Here the anti-noise circuit is connected to the cathode of the detector. When no signal is being received point *A* is not sufficiently positive to overcome the high negative bias of the anti-noise tube so no current flows through the relay winding. However, when a signal is received, point *A* becomes more positive due to more plate current flowing in cathode resistor *R*. This overcomes the bias of the anti-noise tube so that current can flow through the relay winding. This is shown in *Fig. 1* as a bias of *K* on the anti-noise tube. The current in the relay winding causes the relay contacts to close, short-circuiting resistor R_1 in the cathode circuit of the audio tube

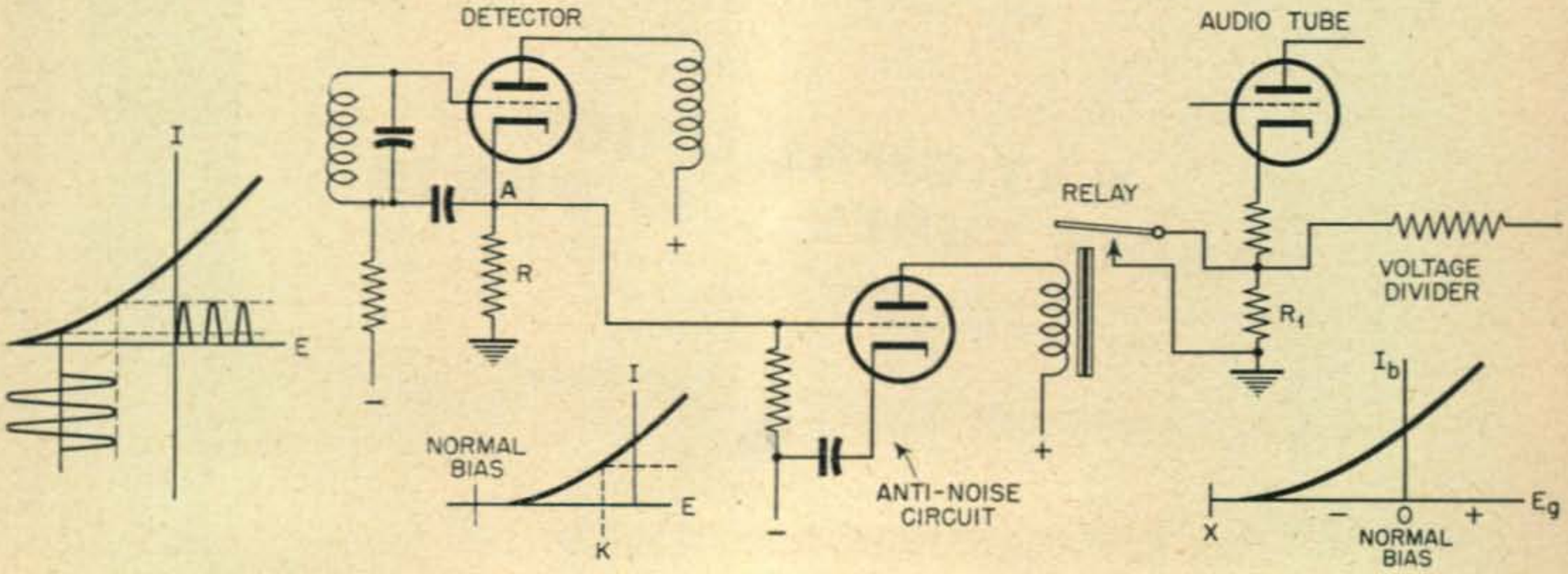
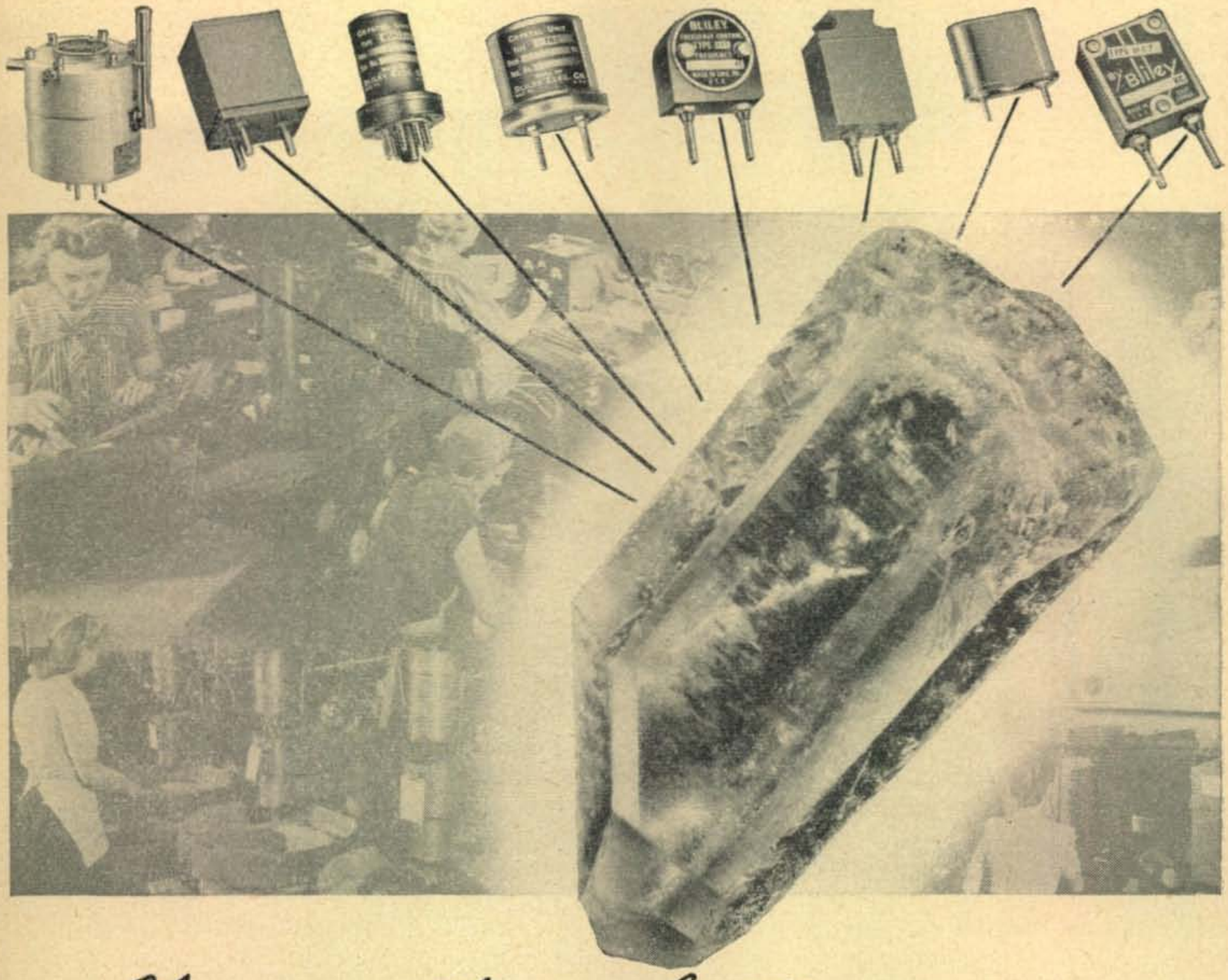


Figure 1



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causing the blocked audio tube to assume normal bias and function normally. When the incoming signal drops to zero, very little current flows in R; and the voltage at A becomes less positive due to lower detector plate current. The bias of the anti-noise tube is beyond cutoff and since voltage at A is almost zero, the anti-noise tube is blocked and no plate current flows through the relay winding. As a result the relay contacts open, R_1 is back in circuit and the audio tube is biased beyond cutoff. This circuit must operate quickly or the first syllable of the modulation may be clipped off if the incoming carrier is modulated when first received.

Obviously the relay contacts might have short circuited the headphones or loud-speaker or cut them out of circuit. *Fig. 2* shows an arrangement

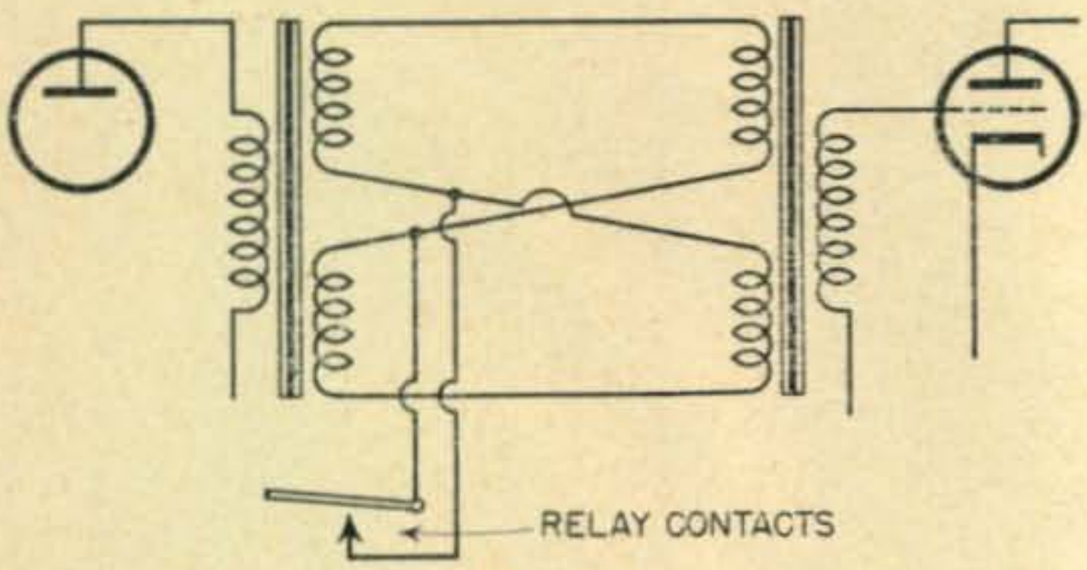

Figure 2

which is also sometimes used to prevent clipping. Here balanced repeater coils are cross-connected in such manner that signals are normally balanced out. The relay contacts are connected in such manner that for normal operation the cross connections are short circuited allowing signal to pass. Thus when the relay contacts are closed the circuit is operative, and when they are open the balanced circuit allows no signal or noise to pass through the repeating coil.

It is at once apparent that the relay contacts of *Fig. 1* could just as well be normally closed and the winding current used to open them. If this were done, then the circuit of *Fig. 2* might be cross-connected to allow signal to flow when the contacts of the relay are open and signal to be balanced out when the contacts are closed. In this case the contacts open more quickly than they can be closed and syllabic clipping may be reduced.

Fig. 3 shows one version of a quiet AVC circuit or QAVC as it is sometimes called. These circuits generally operate on the principle of releasing a large negative bias normally imposed on the grid of the first audio tube. Under conditions of no signal input, the audio tube is biased several volts beyond cutoff so there can be no audio output. When a signal appears, direct current flows through the load circuit of the diode detector increasing the bias on the QAVC tube and correspondingly decreasing its plate current. For best results, the plate current of the QAVC tube should be reduced to zero, thereby removing all blocking bias from the audio tube. The plate current of the QAVC tube flowing through resistor R_1 in grid circuit of the audio tube provides the blocking bias. Resistor R_2 serves to control the signal input required to remove the blocking bias from the audio tube.

In future data sheets, several types of limiters for amplitude modulation receivers will be described and their characteristics discussed. In general, practical limiter circuits are designed to operate without manual adjustment for any amplitude of signal received. Limiters in amplitude modulation receivers are generally most effective on weak signals. Limiters in general consist functionally of an automatic control system and a limiter proper which either opens an audio circuit, short circuits an audio circuit, or balances noise impulses out of the audio frequency system. In this way, noise impulses may be limited to an arbitrary percentage of modulation determined by the values chosen for the circuit constants. Limiters in amplitude modulation receivers operate most effectively on those types of noise which consist of sharp, repetitive impulses. Much man-made interference is of this nature. In the case of "smooth" noise such as tube hiss, thermal agitation, etc., the noise limiter is of no practical value, since the limiter and control system cannot readily distinguish between this type of noise and desired signal.

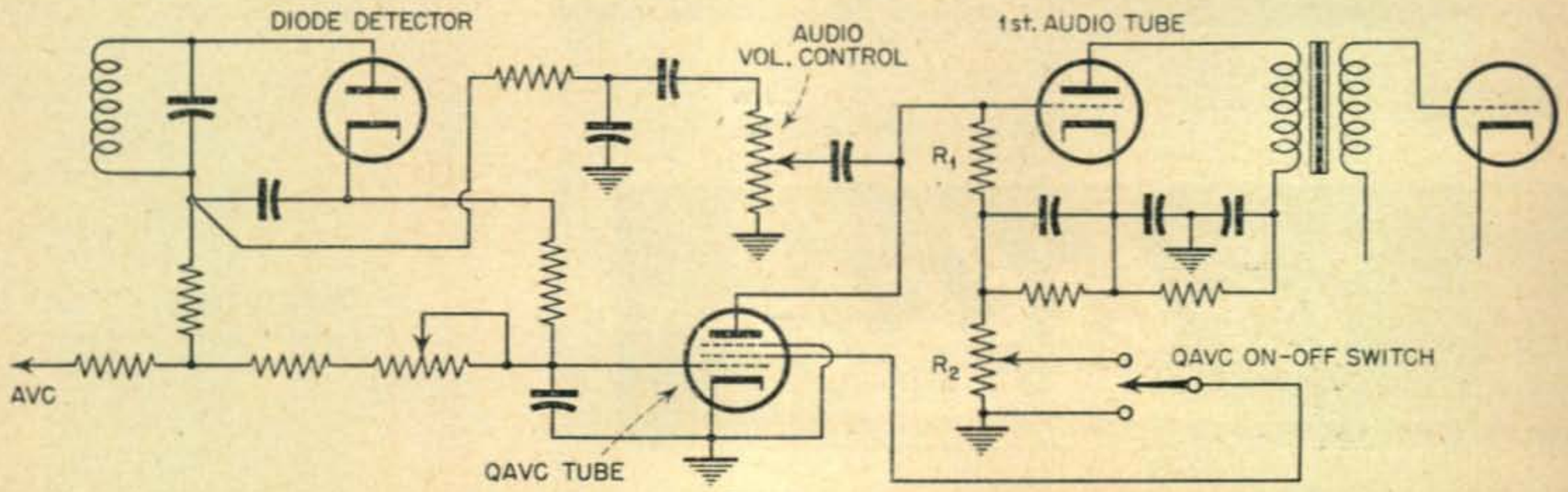

Figure 3

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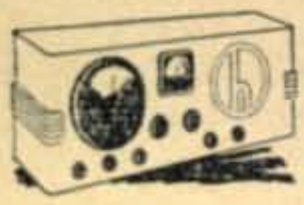

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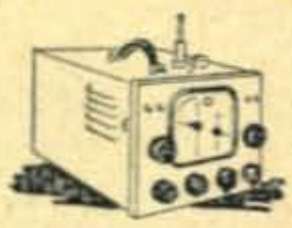

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CRYSTAL CHIRPS

During the hot spell some regrettable errors crept through unnoticed in our June issue. In the schematic on page 8, the output transformer center tap was omitted. A corrected section is

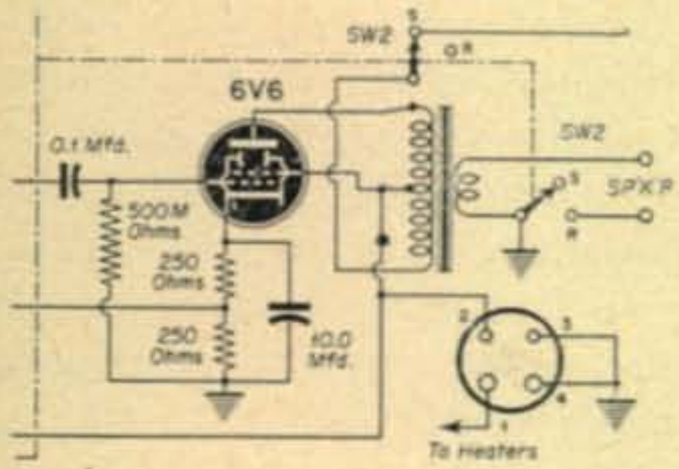

Figure 1

shown in Fig. 1. On page 12, the B plus lead from S2 to the screen grid of the 1T5GT was left out. Just join these two points and it will work OK. On page 17, the lead from point "C" should, of course, connect to the B plus line instead of

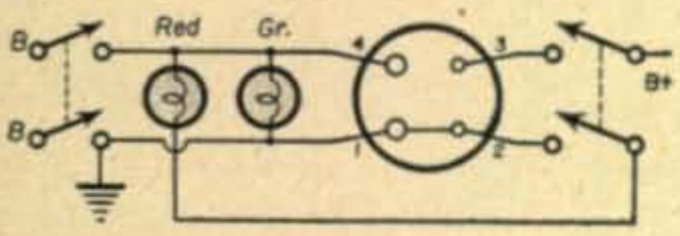

Figure 2

ground, as shown. And, on page 25, a ground lead was omitted. A corrected section of this schematic is shown in Fig. 2.

In the March CQ, page 18, it was stated that "the earth makes one full journey around the sun every twenty-four hours . . ." This was true a good many million years ago — but it takes some 365 times as long now! The statement, of course, should have been to the effect that the earth makes one complete revolution about its axis in twenty-four hours.

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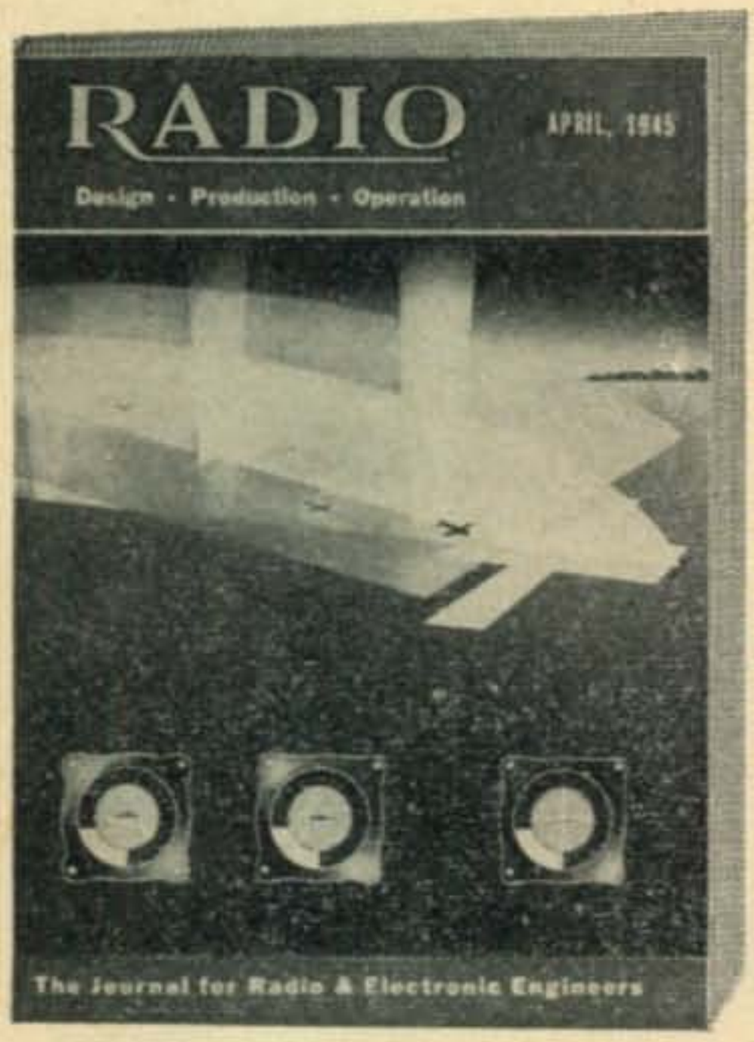

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[Continued from page 26]

sync pulses, there must occur one vertical sync pulse. This vertical sync pulse has the same amplitude as the horizontal sync pulse and is prolonged to endure through some 3 or 4 horizontal sync pulses. The vertical sync pulse does not wipe out these horizontal sync pulses, as this would cause the horizontal generator to slip out of sync while the vertical pulse is present. In order to preserve the continuity of the horizontal pulses, the prolonged vertical pulse is broken up into a series of smaller intervals, each serving as a horizontal pulse. A series of "equalizing" pulses of twice the line scanning frequency is inserted before the vertical pulses to make the effective

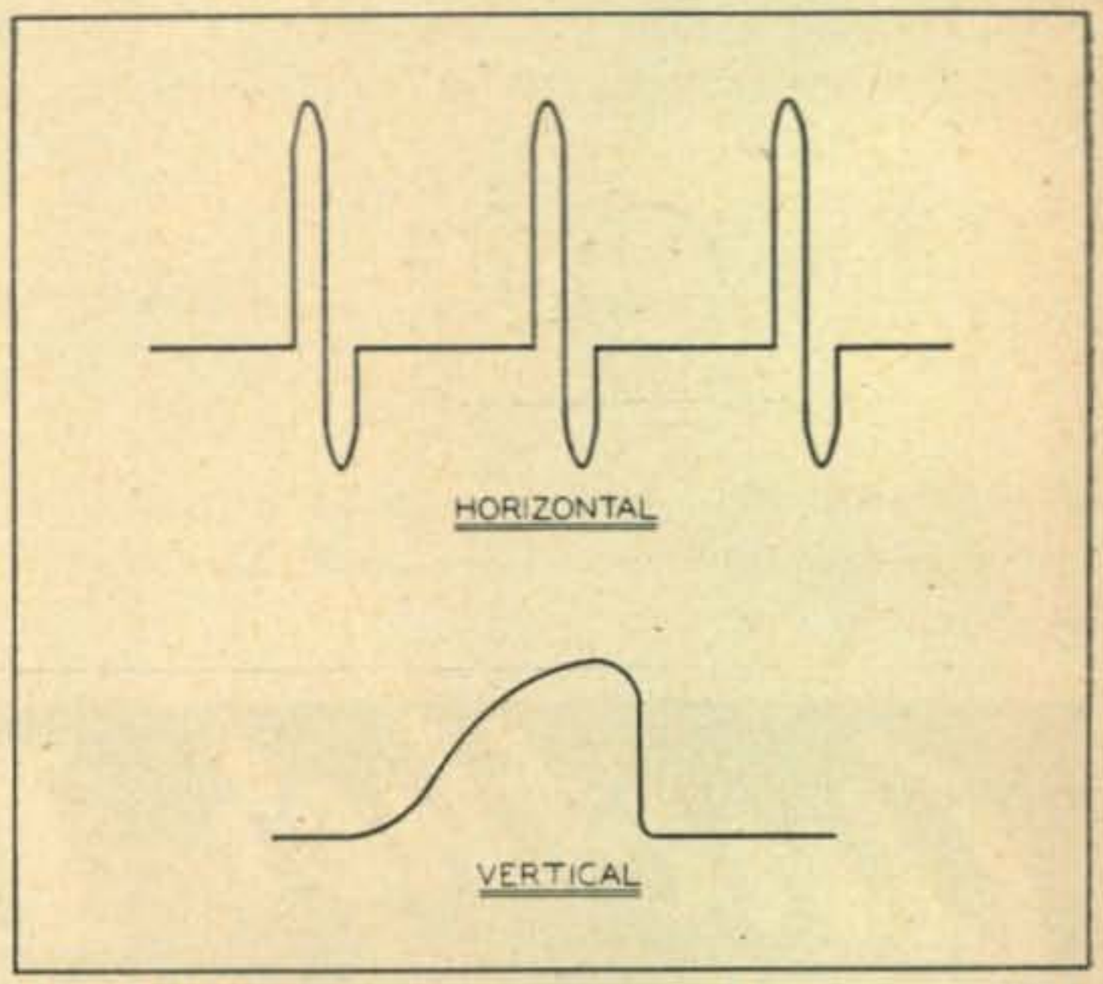

Fig. 12. Oscilloscope waveforms showing separated "sync" signals

shape of each vertical pulse identical, after separation. These pulses occur during the time the scanning beam is blanked out. The vertical sync pulse and equalizing pulses ride on top of the vertical blanking pulse as shown in *Fig. 11*. The ideal shape of any of the sync pulses (plotted against time) should be rectangular. They are, however, trapezoidal in shape, as the rise to the level of control voltage is more or less gradual rather than instantaneous.

The synchronization pulses are generated in the sync generator at the transmitter location and are used to initiate the horizontal and vertical sawtooth scanning generator oscillations. They are combined with the picture and blanking signals which modulate the transmitter. These signals are separated from the picture and blanking signals in the receiver, where they are fed into the scanning generators to lock them in with those at the transmitter. By doing this, the picture on the screen of the cathode ray tube is

an undistorted reproduction of the image focussed on the iconoscope mosaic.

Separating Sync Pulses

When the combined sync signals are received it is necessary that they be separated so that there is no interaction between the horizontal sync pulses and the vertical sawtooth generator, and similarly between the vertical sync pulses and the horizontal generator. This separation is accomplished in a circuit called the "sync separator" stage. After separation, the waveforms of the sync signals when viewed on a test oscilloscope are as shown in *Fig. 12*. The signals illustrated are those occurring with progressive scanning. Sync signals of the interlaced system appear as in *Figs. 10* and *11*.

The sync signals occur in the region which is called the "infra-black" or "blacker than black." Since this region of amplitude is above the black level, the synchronizing signals cannot produce light in the received image. If the peak amplitude of the radio-frequency television signal is taken as 100 per cent, the National Television Systems Committee in 1939 designated as standard the use of not less than 20 per cent, nor more than 25 per cent of this total amplitude for synchronizing pulses.

PHASE

[Continued from page 15

The voltage at the grid will then be in phase with the voltage applied across $L_{p'}$. The grid and plate voltages will again be 180° out of phase and oscillations will occur.

A Volume Expander

The operation of a volume expander (*Fig. 19*) is almost impossible to understand without considering the various phase relationships. The signal voltage from the preceding stage is impressed directly on the cathode of the tube, and is also available to the input of the following stage. In addition, a portion of the signal is rectified by the 6H6, and a d-c voltage, proportional to the amplitude of the signal, is impressed on the grid of the expander. The action of the tube will depend on the grid-to-cathode voltage. Since the grid voltage is fixed negative, and the cathode voltage is in phase with the input signal, when the cathode voltage becomes more positive with respect to ground, the grid-cathode voltage will become more negative, and vice versa. In other words, the grid-cathode voltage is 180° out of phase with the input voltage. The stage is essentially a cathode follower and the output voltage developed is in phase with the grid-cathode voltage. As a result two voltages will appear across the cathode network (the original

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voltage and the voltage developed by the tube 180° out of phase), and these will tend to cancel. This stage will therefore operate as an expander by virtue of the fact that on high signal levels the grid will become sufficiently negative to cut off the cathode follower action, and the stage will pass the input signal to its output with practically no attenuation. At lower levels the output will be reduced as compared with the input.

Antennas

In certain antenna installations, desired effects are obtained by operating two or more antennas "in phase." Such an antenna is shown in *Fig. 21* consisting of two half-waves with a quarter-wave tuned feeder section. The term "in phase" here refers to the fact that when "looking" at the antenna broadside, the waves of current (or voltage) on the two antennas are exactly similar. In other words, all points along the antenna which are the length of one of the elements apart, are in phase. This is in contrast to *Fig. 22* which shows two half-wave sections operating 180° out of phase.

PANORAMIC RECEPTION

[*Continued from page 21*]

band extending 100 kilocycles above and below the center frequency. As the receiver is tuned, the peaks will move across the screen and disappear while new frequencies take their place. But under any conditions, the signal heard on the receiver will always appear at the center of the screen.

Amateur Applications

Either the transmitted signal or the received signal may be easily checked for percentage modulation with the Panadaptor. The signal under test is first picked up on the receiver and the receiver gain or sensitivity so adjusted that a horizontal line half-way up on the screen appears at zero sweep (Panadaptor sweep control set at zero). Modulation is then applied. The horizontal line will break up into a series of vertical deflections, the number depending on the frequency of the modulating source, the amplitudes of which are determined by the percentage modulation. The screen requires calibration with the aid of a cathode-ray oscilloscope or similar instrument, but once calibrated will provide an accurate, rapid check on the modulation of any received signal. Furthermore, if sine-wave modulation is used, distortion becomes immediately apparent and can be analyzed.

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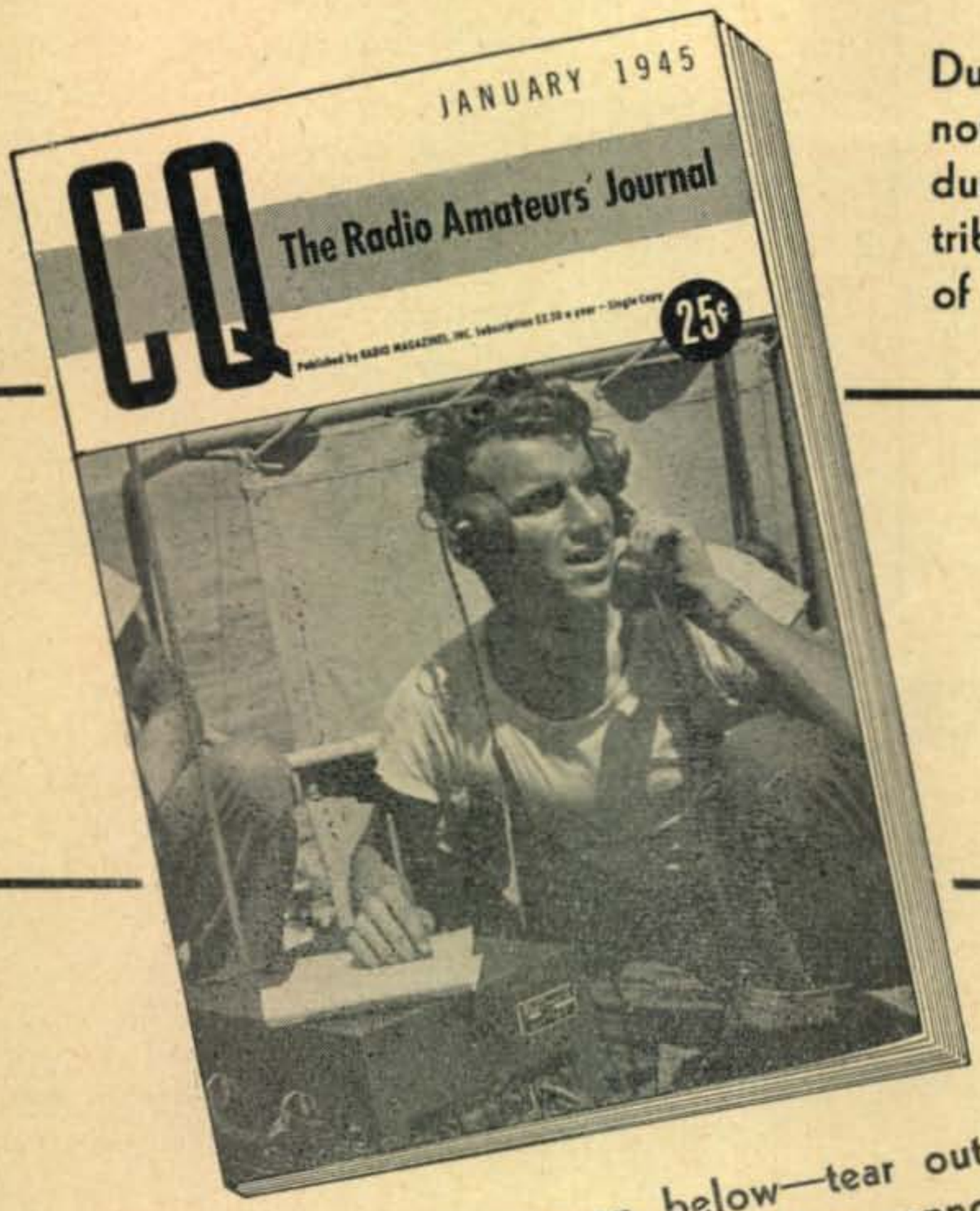

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and down in perfect step with the keying, it is a matter of a little practice before the operator can immediately isolate CQs and his own call letters —from the remaining conglomeration of signal peaks on the panoramic screen. Thus, he can *watch* for CQs or answer to his own CQs without touching the receiver tuning knob. If he wants a three-cornered QSO he can answer the first station that signs by telling him to wait while the second operator continues to call. At the end of the second call, he QSOs both at the same time. Tuning from one to the other is no longer guesswork because all the op has to do is center the deflection in question with a flick of the bandspread tuning condenser on the receiver.

Reading Signal Strength

The Panadaptor is a lagless S-meter for either c.w. or phone. Accurate comparisons on c.w. are possible because there is no mechanical inertia present and the peak voltage of each character is clearly delineated. Calibration of the vertical divisions of the screen in terms of signal strength is very easily accomplished by using any set of arbitrarily chosen stations as comparison markers. It is a real field-strength indicator when applied to signals from beam antennas, and you can help any fellow-operator adjust his directional antenna with a maximum of accuracy and a minimum of effort.

Clean QSOs

Let's take a typical QSO to illustrate this point. W2XXX calls CQ, you spot the call on the Panadaptor, tune quickly to his frequency and call him. When he comes back, your Panadaptor shows another station causing QRM a few kilocycles higher. At your request, W2XXX shifts about 5 kilocycles lower *while you watch* and track with him. He asks for a check on modulation quality and stability. While he is transmitting, you open your Panadaptor SWEEP to zero and observe some residual frequency modulation in his AM signal. W2XXX checks and quickly discovers that his final amplifier is not completely neutralized. A simple adjustment, and he is back on the air with a clean signal. With the Panadaptor still set at zero-sweep, you notice a tendency toward overmodulation on peaks. W2XXX reduces his speech amplifier gain slightly, and this difficulty is immediately cleared up. Thus, each little step is handled uniquely by the Panadaptor and provides the operator with a tool that heretofore was the object of some pretty starry-eyed wishful thinking!

Photographs of an amateur Panoramic receiver by Hallicrafters are shown in *Figs. 14, 15* and *16*—which adequately supplement our technical description. Illustrations *Fig. 17* and *Fig. 18* show army and navy variations of the Panoramic idea.

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EXCITER AND AMPLIFIER

[*Continued from page 10*]

easily obtained from the link-coupled 832 tripler. It is advisable to load the final amplifier, (a 25-watt lamp bulb with short leads will suffice), as the tube may be impaired if it is operated without a load for any length of time. The output or antenna hairpin is again a U about 7 inches long and constructed of ¼" copper tubing.

All the plate and grid copper tubing sections are plated; but not too much difference was noted between the plated and unplated copper rods at this frequency. Corrosion should, of course, be watched for and removed immediately if unplated rods are used. The combined exciter and amplifier units are shown in *Fig. 9*.

Although CCS ratings only are supplied on the 832, and the maximum plate potential is given as 425 volts, this final is being operated ICAS at 500 volts and 60 ma—or 30 watts input. The output lights a 25-watt lamp bulb to about three-quarters of full brilliancy. The efficiency is excellent at this frequency. About 10 or 15 watts of audio will be required to modulate fully the final.

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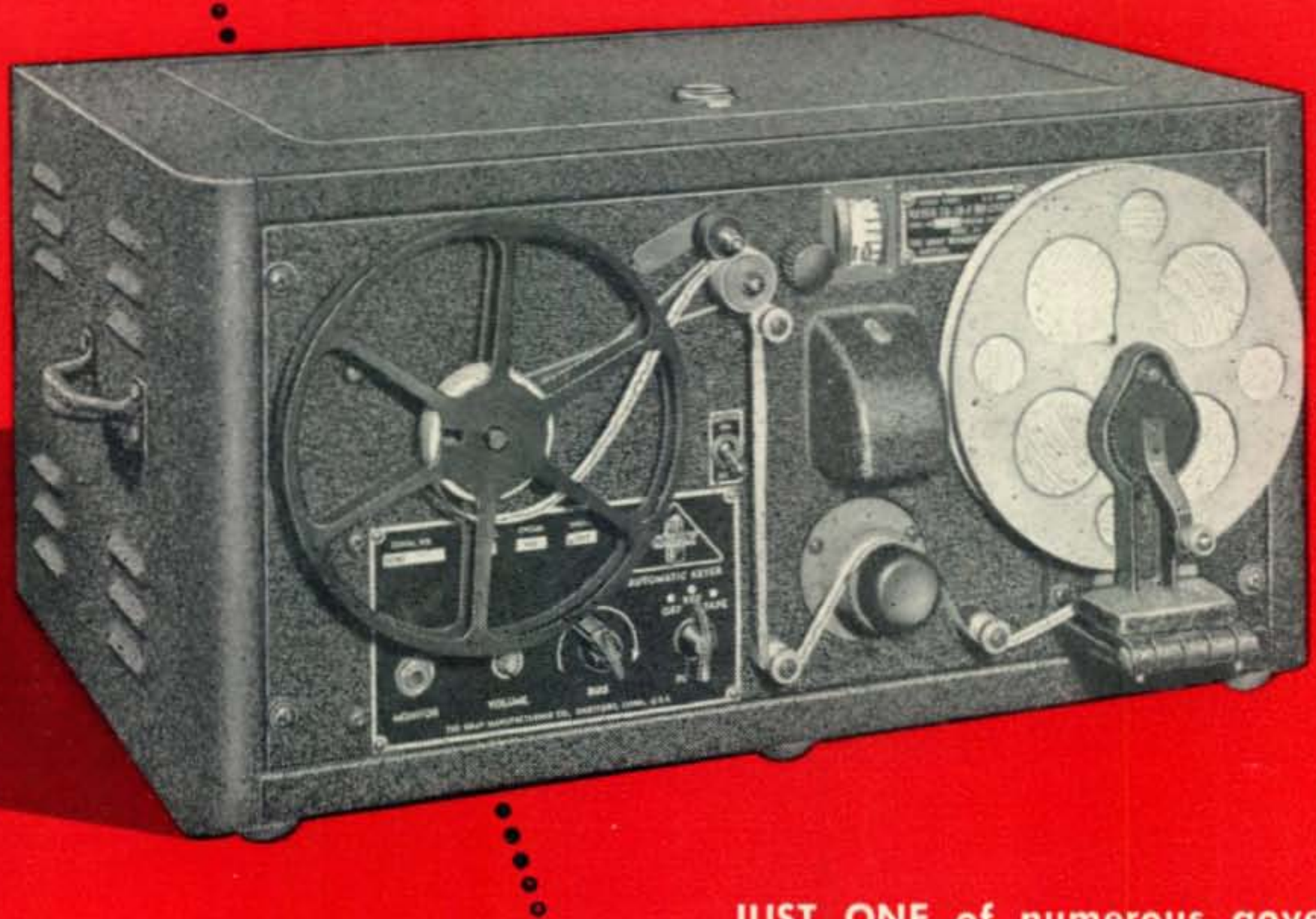

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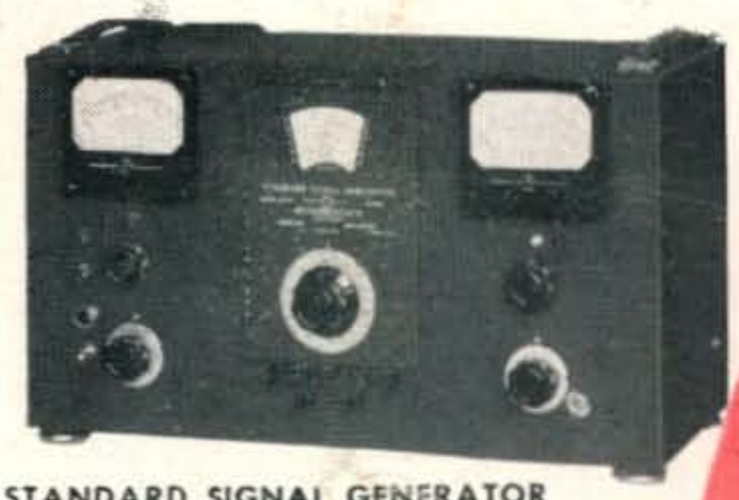

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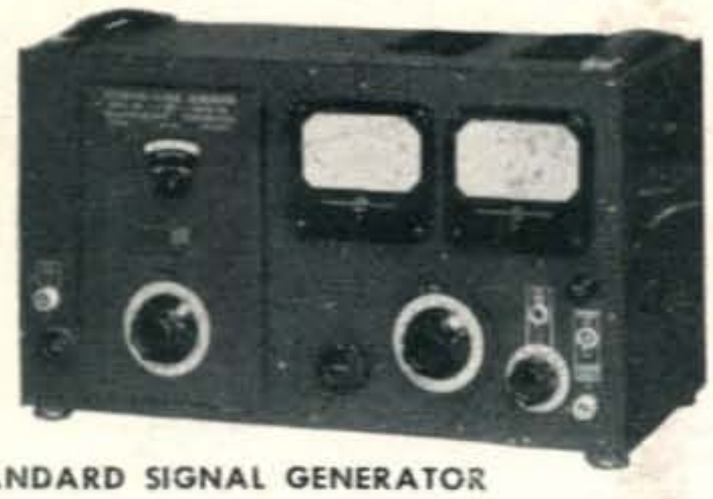

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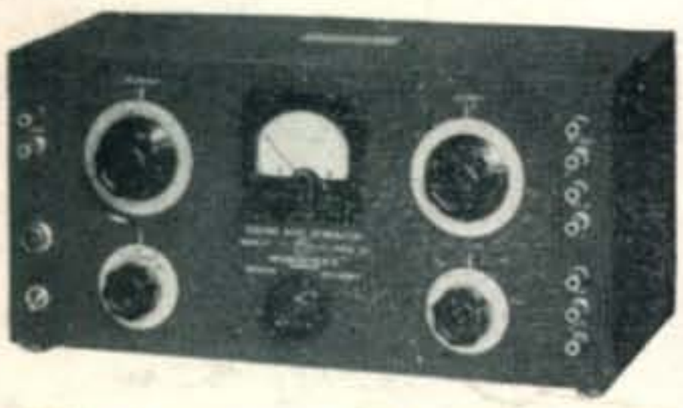

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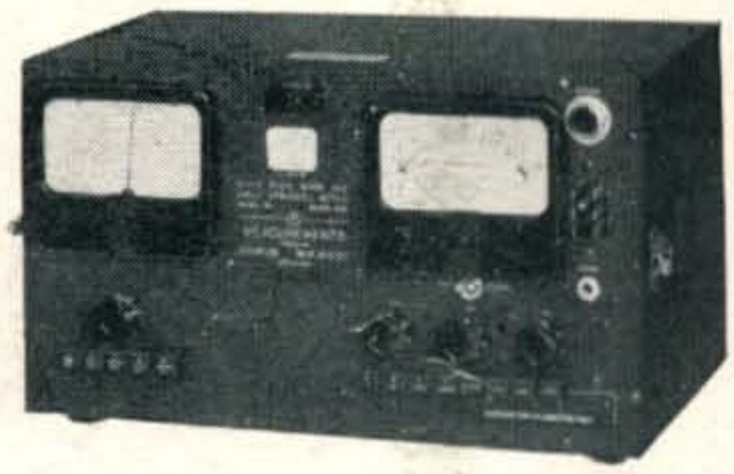

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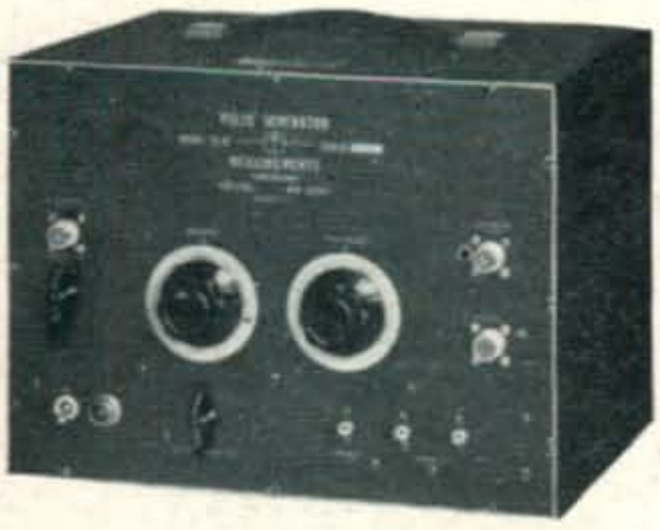

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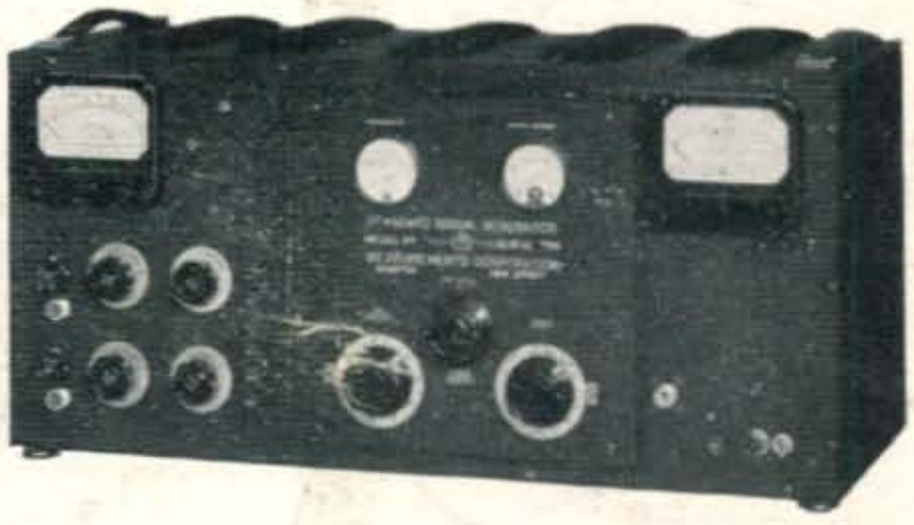

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